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PHYSIOLOGICAL OBSERVATIONS OF MAIZE (ZEA MAYS L.) GENOTYPES DIFFERING IN SOURCE-SINK RATIOS

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Physiological observations of maize (*Zea mays* L.) genotypes differing in source-sink ratios

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INTRODUCTION AND BACKGROUND

Altering the ability of photosynthetic source (leaves) to export assimilate or the ability of sinks (fruit, root, stalk, and/or tiller) to import current or stored assimilate has been shown to alter leaf senescence and leaf CO_2-exchange rate (CER) in many species (Kriedemann et al., 1976). The ratio of source to sink strength seems to exert control on both of these plant processes.

Decreasing source strength by shading or removing the leaves often results in an increase in leaf CER of the remaining leaves (Sweet and Wareing, 1966; Allison and Watson, 1966; Wareing et al., 1968; Thorne and Koller, 1974; Sanders et al., 1977) and a delay in leaf senenscence (Petrie et al., 1939; Maggs, 1964; Hopkinson, 1966; Hodgkinson, 1974).

Many other parameters have been shown to change following source reduction using partial defoliation. RuBP and PEP carboxylase activities and synthesis (Wareing et al., 1968), phosphorylase activity (Thorne, 1979), leaf chlorophyll (Kriedemann et al., 1976), inorganic phosphate (Thorne and Koller, 1974), leaf sugars (Christy and Swanson, 1976), assimilate export (Hartt et al., 1963; Hartt and Kortschak, 1964; Swanson et al., 1976; Troughton, 1976; Chatterton and Silvius, 1979), and amylolytic activity (Haapala, 1969) have all been observed to increase following the reduction of the source. Mesophyll resistance (Thorne and Koller, 1974; Nafziger and Koller, 1976) and leaf starch (Moorby and Milthorpe, 1975) have been shown to decrease.

Decreasing sink strength by reduction or removal of the sink has also been observed to delay leaf senescence in some species (Leopold et al., 1959; Leopold, 1961; Moss, 1962; Mondal et al., 1978; Patterson and Brun, 1980). Inhibition of leaf CER has been observed in small grains (Birecka and Dakic-Wlodkowska, 1963; King et al., 1967), vegetables (Claussen and Biller, 1977; Hall and Milthorpe, 1978), root crops, (Burt, 1964; Nosberger and Humphries, 1965), legumes (Crookston et al., 1974; Mondal et al., 1978), and maize (Kiesselbach, 1948; Moss, 1962). The observed decline in CER may occur from 24 hours to 40 days after sink removal, depending upon the species and method of treatment. Other authors have noted that the decline in CER will occur only if alternative sinks for the photosynthate are removed from the plant (Criswell and Shibles, 1972; Austin and Edrich, 1975; Rawson et al., 1976).

Following sink reduction or removal, chloroplast size (Khan and Sagar, 1969), phaseic and abscisic acids (Kriedemann et al., 1976), mesophyll and stomatal resistances (Crookston et al., 1974; Kriedemann et al., 1976), inorganic phosphate (Mondal et al., 1978), and RuBP carboxylase activity (Mondal et al., 1978), all increased. Leaf export of assimilates (Hartt et al., 1964; Hartt, 1965) has been shown to decrease, whereas leaf sugar (Sayre et al., 1931; Allison and Weinmann, 1970; Hume and Campbell, 1973; Ciha and Brun, 1978) and leaf starch (Kollman et al., 1974) have been shown to increase following sink reduction or removal.

Other authors (Austin, 1972; Habeshaw, 1973; Upmeyer and Koller, 1973; Nafziger and Koller, 1976) have observed an apparent, quantitative relation-

ship between leaf photosynthesis and the level of leaf carbohydrate, suggesting at least partial control of photosynthesis due to feedback inhibition.

The two studies which follow were directed at elucidating relationships between CER and several physiological parameters of the maize plant. These experiments had four general objectives:

1. To determine if and when CER began to change due to ear and/or leaf removal;
2. To investigate relationships between CER and the total nonstructural carbohydrates of the ear leaf and stalk;
3. To determine if partial defoliation hastens or delays physiological maturity in maize kernels;
4. To investigate the effect of genotype on the observations of these experiments.

PART I. THE EFFECT OF EAR REMOVAL AND/OR DEFOLIATION ON CER AND TNC

INTRODUCTION

Under field conditions, the realized rate of photosynthesis is controlled by both internal (photosynthetic pigments and enzymes) and external (light, carbon dioxide, temperature, water, and nutrients) regulatory factors (Zelitch, 1979). Altering the ability of the photosynthetic source (leaves) to export assimilate or the sink (fruit, root, stalk, and/or tiller) to import assimilate has been observed to change photosynthesis in many species (Kriedemann et al., 1976). The ratio of source to sink strength appears to exert control on the realized rate of photosynthesis.

Decreasing the sink demand (ability to import assimilates) by sink removal or reduction in size has been observed by several authors to inhibit photosynthesis in many species (Moss, 1962; Burt, 1964; King et al., 1967; Kriedemann et al., 1976; Mondal et al., 1978) from one to 40 days after treatment. Research by other authors (Chatterton et al., 1972; Habeshaw, 1973; Nafziger and Koller, 1976; Thorne and Koller, 1974) suggests a quantitative relationship between the level of leaf carbohydrate and the realized rate of photosynthesis.

The objectives of this research were to observe:

1. If and when ear removal would reduce CO_2-exchange rate (CER);
2. If a reduction in leaf area would alter the reduction in CER due to ear removal;
3. If there was a relationship between total nonstructural carbohydrate (TNC) and CER due to ear removal.

MATERIALS AND METHODS

The experiments were conducted at the Agronomy Research Farm near Ames, Iowa in 1978 and 1979 on Clarion (Typic Hapludoll, fine-loamy mixed mesic) soils. The experiment was hand-planted on May 5 both years and arranged in a split plot design with genotypes as main plots using four replications. Fertility consisted of 202 kg nitrogen ha^{-1} incorporated prior to planting and 80 kg phosphorus and potassium ha^{-1} plowed down the previous fall. Weed control consisted of an initial application of Alachlor herbicide and subsequent hand-weeding. Plots were overplanted and thinned to a density of 40,000 plants per ha. Rows were 4.1 m long, 76.2 cm wide, with 33.0 cm between plants in the row.

In 1978, one maize hybrid (B73 X Mo17) was used in the experiment based on previously observed effects of defoliation and ear removal (R. B. Pearce, unpublished research, Dept. of Agronomy, Iowa State University). Q97 X Q98, a two-eared hybrid, was added in 1979.

The treatments were as follows: 1) control, no leaves or ears removed; 2) ear(s) removed; and 3) ears removed and 50 percent defoliation (every other leaf blade removed). Each treatment was imposed on one plant per row at three weeks after 50 percent of the plants had ears with exposed silks (50 percent silking). All treatments were located in the same row. All tillers were removed to eliminate possible alternative sinks which might bias the treatment effects.

Sampling Procedure and Measurement

Samples were collected for CO_2-exchange rate (CER) and total non-structural carbohydrate (TNC). Collection began on the day of treatment.

In 1978, samples were collected every day for 10 days. In 1979, samples were collected every three days for 15 days.

Carbon dioxide exchange rate (CER) was measured on two leaves per plant, the second leaf from the tassel and the ear leaf. Samples were collected at 0830 and 1000 hours CDST. The leaves were excised; placed in moist paper towels; and transported to the laboratory in a styrofoam chest. The CER was measured by using the air-sealed chamber method of Pearce et al. (1976). Briefly, this method consists of cutting a 1.6 X 11.7 cm section from each leaf with a leaf punch. The leaf section was placed in a supporting plastic frame and inserted into a preconditioning chamber. The sections were preconditioned for 25 to 30 minutes at a photosynthetic photon flux density (PPFD) of 1,000 $\mu E\ m^{-2}\ sec^{-1}$. The CER of each leaf section was measured by differential gas analysis using a Beckman Infrared Gas Analyzer (Model No. 865) at a PPFD of 2,000 $\mu E\ m^{-2}\ sec^{-1}$. The air temperature of the measuring chamber was maintained at 27 $\pm$ 1C. Ambient air was used which ranged from 320 to 340 ppm CO_2. The CER was calculated according to Hesketh and Moss (1963).

Total nonstructural carbohydrates (TNC) were determined for two stalk positions and the ear leaf (1979 only). One stalk position was the top three nodes, which consisted of a section 2.5 cm above the top leaf node down to 2.5 cm below the third leaf node. The other stalk position was the ear node which consisted of the ear node and one-half of the internode immediately above and below the ear node. The ear leaf sample consisted of all leaf tissue beyond 15.2 cm from the collar region. Samples were

collected at 0800 and 1000 hours CDST and immediately transported to the laboratory. Samples were dried at 100C for one hour and then dried to constant weight at 60C. The dried samples were ground to pass through a 40-mesh screen and stored until analysis in capped, glass bottles. Samples were again dried overnight at 60C before proceeding with the following carbohydrate extraction. A 500 mg sample was placed in a 125 X 25 cm glass test tube, to which 25 ml of 0.8 N sulfuric acid was added. The tube was placed in a boiling water bath for one hour. After one hour, the tube was cooled at room temperature for five to eight minutes and then filtered through Whatman No. 42 filter paper into a 100 ml volumetric flask. The filtrate was neutralized with 20 ml 0.8 N sodium hydroxide and brought to volume with distilled water. A 0.25 ml sample of the extracted carbohydrate solution was added to a test tube containing 0.75 ml of distilled water. The resulting solution was then analyzed using the Somogyi-Nelson spectrophometric method (Nelson, 1944; Somogyi, 1945).

Feedback inhibition was defined as the decline in leaf CER following ear removal and/or 50 percent defoliation due to sink feedback control which regulated CO_2 assimilation.

RESULTS

After ear removal there was a decline in leaf CER, but not until five to 12 days had elapsed from ear removal. Leaf position had a greater affect than genotype.

When ears were removed from B73 X Mo17 in 1978, the CER of the second leaf (Figure 1), when compared to control plants, began to decline six days after ear removal and continued to decline. The ear leaf also declined in CER, but it was not as apparent or significant as the second leaf. With the exception of two sampling dates, ear removal plus 50% defoliation had CERs intermediate to ear removal and control treatments.

In 1979, ear removal inhibited the CER of the second leaf (Figure 2) for both Q97 X Q98 and B73 X Mo17. For Q97 X Q98, CER inhibition occurred six days after ear removal, and 12 days after ear removal for B73 X Mo17. The CER of the ear leaf did not seem to be affected by ear removal for Q97 X Q98. For B73 X Mo17, the CER of the ear leaf declined nine days after ear removal, but the decline was not as much as that shown by the second leaf. With the exception of three sampling dates, the ear removal plus 50% defoliation treatment had CERs intermediate to the control and ear removal treatments.

For the period of these experiments, there was no increase in the percent TNC in stalks and leaves. Correlations between CER and TNC for both years are presented in Table 1. The 1978 study had all positive correlations, whereas the 1979 study had mainly negative correlations. The data show that TNC of leaves or stems had very little influence on the

Figure 1. Carbon dioxide exchange rate (CER) (mg CO_2 dm^{-2} hr^{-1}) of the second leaf from the tassel (A) and the ear leaf (B) at each collection of field-grown single plants of B73 X Mo17 (1978 season); expressed as the mean of four replications. The vertical bars indicate the standard error for each treatment

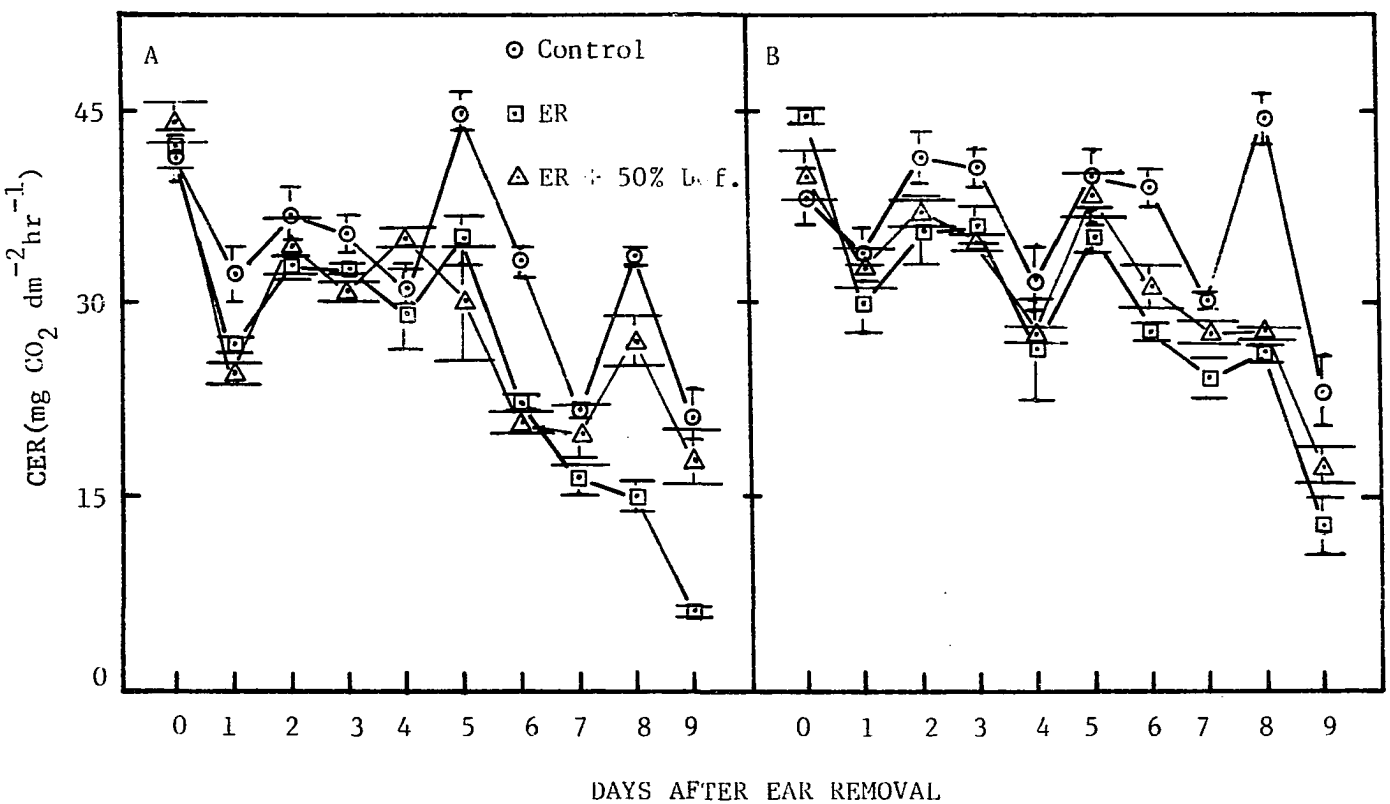

A
B
Control
ER
ER + 50% Def.
CER(mg CO_2 $dm^{-2}hr^{-1}$)
45
30
15
0
0 1 2 3 4 5 6 7 8 9
0 1 2 3 4 5 6 7 8 9
DAYS AFTER EAR REMOVAL

Figure 2. Carbon dioxide exchange rate (CER) (mg CO_2 dm^{-2} hr^{-1}) of the second leaf from the tassel (A) and the ear leaf (B) at each collection of field-grown single plants for B73 X Mo17 and Q97 X Q98 (1979 season); expressed as the mean of four replications. The vertical bars indicate the standard errors for each treatment

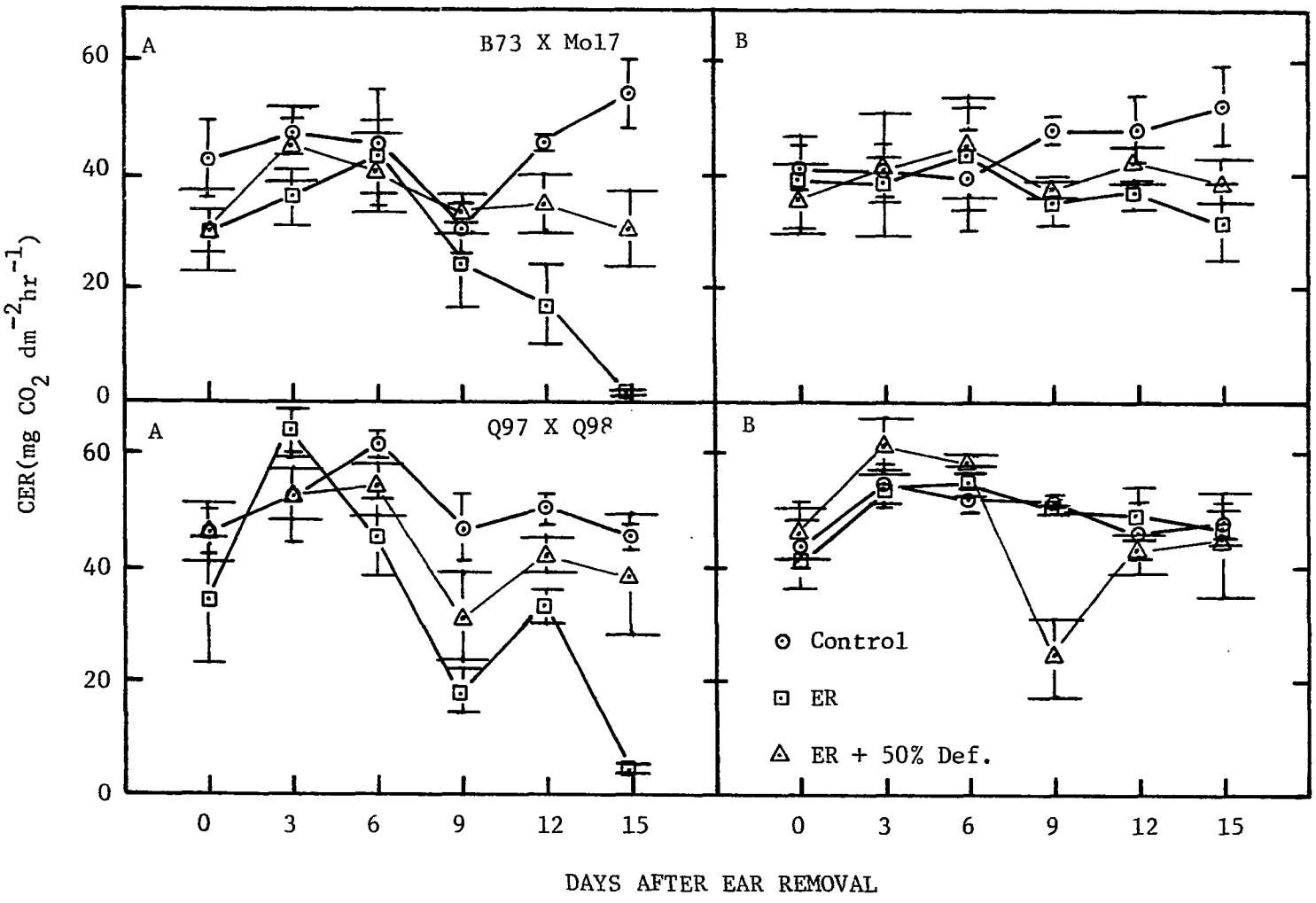

A
B73 X Mo17
B
A
Q97 X Q98
B
Control
ER
ER + 50% Def.
CER(mg CO_2 $dm^{-2}hr^{-1}$)
0
20
40
60
0
3
6
9
12
15
DAYS AFTER EAR REMOVAL

Table 1. Correlation coefficients comparing the CER of the second leaf and the ear leaf with the %TNC of the bulk sample of the top three nodes, ear leaf, and the singular ear node, 1978 and 1979 seasons

Variable	Variety	CER of the Second Leaf	CER of the Ear Leaf
Top Three Nodes	B73 X Mo17 (1978)	0.15	0.12
	B73 X Mo17 (1979)	-0.18	-0.30*
	Q97 X Q98	-0.27**	-0.22†
Ear Node	B73 X Mo17 (1978)	0.28**	0.28**
	B73 X Mo17 (1979)	-0.21†	-0.19
	Q97 X Q98	-0.21†	-0.25**
Ear Leaf	B73 X Mo17	-0.14	-0.20
	Q97 X Q98	-0.44**	-0.22†

†, *, **Significant at the 0.10, 0.05, and 0.01 levels, respectively.

leaf CER of maize, and that ear removal had little effect on the TNC of the ear leaf or stalk during the two weeks following ear removal.

DISCUSSION

After five to 12 days, ear removal caused a decline in second leaf CER due to feedback inhibition. Moss (1962) observed a decline of 25% in the whole plant CER (10 plants per plot) of maize after seven days when fully-developed ears were removed. Time requirements for feedback inhibition of CER have also been observed in other species: potatoes (Burt, 1964) and pepper (Kriedemann et al., 1976). However, sink removal in wheat (King et al., 1967) and soybeans (Mondal et al., 1978) has been observed to decrease leaf CER within 24 hours. The apparent discrepancy between species in the time to feedback inhibition of leaf CER can be explained. If no other sink, except the fruit, is available for the photosynthate, then the decline in CER can occur within 24 hours. However, secondary sinks such as the stem, roots, and/or tillers are capable of altering the normal, translocation. If this alteration is established, the decline in leaf CER will occur when the secondary sinks become filled with the products of photosynthesis.

Since the secondary sinks (stalk and roots) are primarily below the ear leaf in maize (Eastin, 1969), the sources (leaves) farthest from these sinks might be expected to show feedback inhibition first when there is a reduction in sink demand. The data from this experiment support this hypothesis, because the second leaf declined in CER before the ear leaf, after ear removal. Simply stated, this information would indicate that when sinks become filled and have a reduced demand for photosynthate, then the CER of those sources closest to the sink will be affected less than those more distant.

When one-half of the leaves plus the ears were removed, leaf CER was usually intermediate between the control and plants without ears. This manipulation reduced both the sink and the sources for photosynthate in the plant. If alternative sinks below the ear leaf were capable of storing the reduced level of photosynthate, CER would not be reduced as much as observed with ear removal. Similar results were shown when King et al. (1967), who shaded the leaf below the flag leaf of wheat plants without ears, observed an increase in the CER of the flag leaf.

The TNC of the middle and upper stalk, and the ear leaf, did not correlate with changes in CER. The TNC was not increased by ear removal, and had very little influence on leaf CER. The TNC of the lower stalk could possibly be a more sensitive measure of the changes occurring in leaf CER and alternative sinks.

PART II. THE EFFECT OF ALTERATION IN THE SOURCE-SINK RATIO ON VARIOUS PHYSIOLOGICAL PARAMETERS

INTRODUCTION

Altering the ability of the photosynthetic source (leaves) to export assimilate (source strength) or the sink (fruit, root, stalk, and/or tiller) to import current or stored assimilate has been shown to change the rates of both leaf senescence and photosynthesis in many species (Kriedemann et al., 1976). The ratio of source to sink strength appears to exert control on these two plant processes.

Decreasing the sink demand (ability to import assimilates) by fruit removal or reduction in size has been observed to delay leaf senescence (Leopold et al., 1959; Leopold, 1961; Moss, 1962) and inhibit photosynthesis in several species (Kiesselbach, 1948; Burt, 1964; King et al., 1967; Mondal et al., 1978). Decreasing the source by shading or removal of the leaves has also been shown to delay leaf senescence (Hopkinson, 1966; Hodgkinson, 1974) and increase photosynthesis (Allison and Watson, 1966; Wareing et al., 1968).

Other authors have observed a quantitative relationship between the level of leaf carbohydrate and the reduction in photosynthesis (Chatterton et al., 1972; Habeshaw, 1973; Thorne and Koller, 1974; Nafziger and Koller, 1976).

This experiment had five objectives:

1. To determine if and when CER began to change due to defoliation and/or ear removal;
2. To investigate relationships between CER and the total nonstructural carbohydrates of the stalk;

3. To determine how the stalk, leaves, and sheaths were altered;
4. To determine if the imposed treatments delayed leaf senescence;
5. To investigate the effect of genotype on the observations of this experiment.

MATERIALS AND METHODS

The experiments were conducted at the Agronomy Research Farm near Ames, Iowa in 1978 and 1979 on Clarion (Typic Hapludoll, fine-loamy mixed mesic) soils. The experiment was hand-planted on May 5 both years and arranged in a split-plot design with genotypes as main plots using eight replications. Fertility consisted of 202 kg nitrogen ha^{-1} incorporated prior to planting and 80 kg of phosphorus and potassium ha^{-1} plowed down the previous fall. Weed control consisted of an initial application of Alachlor herbicide and subsequent hand-weeding. Plots were overplanted and thinned to a density of 40,000 plants per hectare. Rows were 4.1 m long, 76.2 cm wide with 33.0 cm between plants in the row.

Three maize inbreds (BSSS 56, BSSS 114, and BSSS 133) and two hybrids (B73 X Mo17 and Q97 X Q98) were used in the experiment because of previously observed effects of defoliation and ear removal (R. B. Pearce, unpublished research, Dept. of Agronomy, Iowa State University).

The following treatments were imposed on the maize genotypes two weeks after 50% of the plants had ears with exposed silks (50% silking). 1) No leaves removed, control; 2) Every third leaf blade removed, 25% def.; 3) Every other leaf blade removed, 50% def.; 4) All leaves removed except the second leaf and ear leaf, 75% def.; 5) Ear(s) removed; and 6) Ear(s) removed and every other leaf blade removed, ear removal and 50% def. All treatments were located in the same row. All tillers were removed to eliminate possible alternative sinks which might bias the treatment effects.

Sampling Procedure and Measurement

Sample collections were made every ten days after initial treatments until the individual treatment plants had lost their green color. Samples were collected for measurements of carbon dioxide exchange rate (CER), dry matter distribution, and total nonstructural carbohydrates (TNC).

Carbon dioxide exchange rate (CER) was measured on two leaves, the second leaf from the tassel and the ear leaf. Samples were collected between 0800 to 1100 hours CDST. The leaves were excised; placed in moist paper towels; and transported to the laboratory in a styrofoam chest. The CER was measured by using the air-sealed chamber method of Pearce et al. (1976). A rectangular leaf section of 1.6 cm X 11.7 cm was made from each leaf with a leaf punch. The leaf section was placed in a supporting plastic frame and inserted into a preconditioning chamber. The sections were preconditioned for 25 to 30 minutes at a photosynthetic photon flux density (PPFD) of 1,000 $\mu E\ m^{-2}\ sec^{-1}$. The CER of each leaf section was measured by differential gas analysis using a Beckman Infrared Gas Analyzer (Model No. 865) at a PPFD of 2,000 $\mu E\ m^{-2}\ sec^{-1}$. The air temperature of the measuring chamber was 27 $\pm$ 1C. Ambient air was used which ranged from 320 to 340 ppm CO_2. The CER was calculated according to Hesketh and Moss (1963).

Dry matter distribution of plant samples was measured by cutting the plant just above the soil surface; separating the plant into stalk, leaves, sheaths, and ears (grain and cob); drying the sample at 60C for seven days; and then weighing each dried sample. All plants were cut between 1100 and 1300 hours CDST.

Total nonstructural carbohydrates (TNC) were determined for two stalk positions. One stalk position was the top three nodes, which consisted of a section 2.5 cm above the top leaf node down to 2.5 cm below the third leaf node. The other stalk position was the ear node which consisted of the ear node and one-half of the internode immediately above and below the ear node. Samples were collected at 0830 and 1030 hours CDST and immediately transported to the laboratory. Samples were dried at 100C for one hour and then dried to constant weight at 60C. The dried samples were ground to pass through a 40-mesh screen and stored until analysis in capped, glass bottles. Samples were again dried overnight at 60C before proceeding with the following carbohydrate extraction. A 500 mg sample was placed in a 125 X 25 cm glass test tube, to which 25 ml of 0.8 N sulfuric acid was added. The tube was placed in a boiling water bath for one hour. After one hour, the tube was placed in a boiling water bath for one hour. After one hour, the tube was cooled at room temperature for five to eight minutes and then filtered through Whatman No. 42 filter paper into a 100 ml volumetric flask. The filtrate was neutralized with 20 ml 0.8 N sodium hydroxide and brought to volume with distilled water. A 0.25 ml sample of the extracted carbohydrate solution was added to a test tube containing 0.75 ml of distilled water. The resulting solution was then analyzed using the Somogyi-Nelson spectrophometric method (Nelson, 1944; Somogyi, 1945).

Days to physiological maturity (PM) was measured as the days from 50 percent silking to when 75 percent of the ears had kernels with black layers formed.

Harvest parameters were determined by harvesting ears of four plants per treatment. The harvested ears were dried at 60C for three days. The grain was then removed from the cob. Cob weight, grain weight, and 100-kernel weight were recorded. For Q97 X Q98, the secondary ear was measured and recorded separately.

Leaf senescence was defined as the days from treatment to when leaves of treatment plants had 90 percent of the leaf area discolored by cholorsis and necrosis.

Feedback inhibition was defined as the decline in leaf CER following ear removal and/or 50 percent defoliation due to sink feedback control which regulated CO_2 assimilation.

RESULTS

When leaves were removed, the CER of both leaf positions was increased by 10 days after treatment for BSSS 56 and BSSS 133 (Table 2). Both of these genotypes have low grain yield (See Table 5) which seemed to be the main requirement for observing any treatment effect of leaf removal on leaf CER. The other genotypes used in this study had larger grain yields, and CER was not changed by defoliation.

When ears were removed, the CER of both leaf positions for most genotypes began to decline by 10 days after treatment and continued to decline when compared to control plants (Table 2). The exceptions were BSSS 133 which showed no decline in either leaf position, and Q97 X Q98 which showed no decline at the ear leaf position.

When ear plus 50 percent of the leaves were removed, the CER of both leaf positions for BSSS 114 and B73 X Mo17 began to decline by 10 days after treatment, and was usually intermediate to control plants and plants without ears. This was also true for the second leaf for Q97 X Q98. Apparently, the removal of 50 percent of the leaves partially altered the inhibitory effect of ear removal by shifting the source-sink balance back toward that of control plants.

The percent TNC of the stalk was expected to decrease after partial defoliation, whereas ear removal and ear removal plus 50 percent defoliation was expected to increase the stalk TNC. This supposition was substantiated by the data (Table 3). All defoliation treatments decreased the percent TNC of both stalk positions by 10 to 20 days after treatment.

Table 2. Carbon dioxide exchange rates (mg CO_2 $dm^{-2}hr^{-1}$) of the second leaf from the tassel and the ear leaf of maize plants as affected by treatment and genotype, both seasons

	Second leaf from the tassel				Ear leaf			
	----Days after treatment----				----Days after treatment----			
	10	20	30	40	10	20	30	40
	----------mg CO_2 $dm^{-2}hr^{-1}$----------							
BSSS 56								
Control	29.6	19.6	10.5	-[a]	26.9	19.7	7.2	-
25% Def.	36.2	26.2	3.1	-	31.7	22.1	4.6	-
50% Def.	33.4	27.2	5.3	-	30.3	23.2	8.3	-
75% Def.	36.9	25.2	-	-	31.7	21.4	-	-
ER	17.8	11.9	-	-	20.2	14.3	-	-
ER + 50% Def.	30.2	19.1	-	-	23.5	17.0	-	-
LSD .05	5.3	3.5	4.1		3.5	4.3	5.4	
BSSS 114								
Control	16.7	13.6	6.2	-	17.6	12.2	7.9	-
25% Def.	17.7	11.3	3.0	-	16.3	11.0	1.4	-
50% Def.	17.4	11.4	4.0	-	17.1	12.6	1.6	-
75% Def.	14.4	8.1	-	-	16.1	8.6	-	-
ER	13.4	3.3	0.3	-	13.5	8.3	1.0	-
ER + 50% Def.	13.9	9.5	4.7	-	12.9	8.9	4.1	-
LSD .05	2.1	2.7	2.3		2.2	1.9	1.7	

[a]Treatment senesced or not sampled.

Table 2. (Continued)

	Second leaf from the tassel				Ear leaf			
	----Days after treatment----				---Days after treatment---			
	10	20	30	40	10	20	30	40
	----------mg CO_2 $dm^{-2}hr^{-1}$----------							
BSSS 133								
Control	12.0	7.5	2.8	-	21.0	13.5	2.4	-
25% Def.	19.5	17.7	3.5	-	17.3	17.0	9.4	-
50% Def.	21.8	9.7	2.9	-	23.7	22.8	9.0	-
75% Def.	21.1	18.6	-	-	23.7	21.5	-	-
ER	14.8	5.6	-	-	17.4	12.1	-	-
ER + 50% Def.	15.3	8.9	-	-	17.1	11.1	-	-
LSD .05	3.9	3.9	2.2		5.1	4.1	4.5	
B73 X Mo17								
Control	40.2	40.0	20.7	7.6	45.5	40.3	27.6	21.1
25% Def.	43.6	40.3	23.8	10.6	46.1	39.0	28.1	21.4
50% Def.	41.2	42.0	30.4	7.5	44.7	41.0	37.1	9.4
75% Def.	45.2	27.6	-	-	46.9	34.5	-	-
ER	27.5	15.7	1.2	-	33.0	20.4	6.3	-
ER + 50% Def.	34.1	18.3	1.7	-	33.9	22.5	8.3	-
LSD .05	5.5	6.0	2.6	5.5	6.1	6.0	4.3	5.9

Table 2. (Continued)

	Second leaf from the tassel				Ear leaf			
	----Days after treatment----				----Days after treatment--			
	10	20	30	40	10	20	30	40
	----------mg CO_2 $dm^{-2}hr^{-1}$----------							
Q97 X Q98								
Control	43.9	36.7	25.9	19.5	39.3	38.2	29.2	19.5
25% Def.	41.2	35.5	22.1	-	40.5	38.7	26.3	-
50% Def.	41.7	36.2	12.5	6.0	38.9	38.0	18.5	6.0
75% Def.	37.6	33.2	-	-	43.6	34.1	-	-
ER	34.2	13.4	8.6	25.4	34.3	33.3	30.8	25.4
ER + 50% Def.	37.1	33.4	20.8	21.8	39.5	37.8	34.3	21.8
LSD .05	4.6	5.1	4.6	4.1	3.8	5.8	4.1	8.1

Table 3. The %TNC (mg glucose equiv./ 100 mg sample) of the top three nodes and the singular ear node of maize plants as affected by treatment and genotype, both seasons

	Top three nodes				Ear node			
	----Days after treatment----				----Days after treatment-----			
	10	20	30	40	10	20	30	40
	----------%TNC (mg glucose equiv./ 100 mg sample)----------							
BSSS 56[a]								
Control	23.0	32.0	15.3	-[b]	34.5	37.3	15.3	-
25% Def.	33.0	29.0	13.0	-	33.8	36.0	13.0	-
50% Def.	31.0	24.3	16.8	-	24.5	28.8	16.8	-
75% Def.	21.3	13.5	-	-	21.3	18.3	-	-
ER	27.8	33.8	-	-	28.8	20.3	-	-
ER + 50% Def.	41.0	27.3	-	-	47.0	35.3	-	-
LSD .05	6.5	5.8	5.1		4.4	3.9	4.6	
BSSS 114								
Control	25.3	31.8	28.6	-	27.3	28.1	26.9	-
25% Def.	27.5	30.5	27.0	-	31.5	30.1	25.3	-
50% Def.	27.5	24.1	20.8	-	28.0	22.9	20.1	-
75% Def.	24.9	23.4	-	-	27.0	15.8	-	-
ER	37.1	33.1	34.9	-	33.8	30.3	33.1	-
ER + 50% Def.	33.6	30.6	34.9	-	34.9	30.1	35.8	-
LSD .05	3.7	5.1	2.9		2.1	4.0	4.2	

[a]Data from 1978 only.

[b]Treatment senesced or not sampled.

Table 3. (Continued)

	Top three nodes				Ear node			
	----Days after treatment----				----Days after treatment-----			
	10	20	30	40	10	20	30	40
	----------%TNC (mg glucose equiv./ 100 mg sample)---------							
BSSS 133[a]								
Control	31.3	32.8	33.0	-	24.3	33.0	29.8	-
25% Def.	30.8	16.0	31.3	-	34.8	24.0	31.8	-
50% Def.	34.0	41.8	-	-	36.8	35.8	25.8	-
75% Def.	24.3	44.8	-	-	34.3	39.0	-	-
ER	36.3	42.5	-	-	33.0	33.8	-	-
ER + 50% Def.	33.5	38.8	-	-	33.0	36.3	-	-
LSD .05	4.6	2.9	3.8		4.4	4.3	3.3	
B73 X Mo17								
Control	29.1	26.8	22.8	21.5	36.9	33.1	31.8	20.9
25% Def.	28.3	22.6	18.9	15.0	32.6	27.8	26.1	20.3
50% Def.	25.4	15.1	12.8	6.0	31.0	20.4	17.5	16.0
75% Def.	32.3	16.4	8.5	-	24.0	12.3	11.5	-
ER	37.4	31.5	33.5	-	44.4	31.5	32.3	-
ER + 50% Def.	46.9	28.3	30.1	-	35.6	30.9	33.0	-
LSD .05	4.0	3.0	2.4	12.3	3.5	3.8	2.7	3.8

Table 3. (Continued)

	Top three nodes				Ear node			
	----Days after treatment----				----Days after treatment-----			
	10	20	30	40	10	20	30	40
	----------%TNC (mg glucose equiv./ 100 mg sample)----------							
Q97 X Q98								
Control	22.6	19.1	23.4	20.9	28.5	27.0	27.4	17.6
25% Def.	18.6	16.1	13.0	-	20.8	14.4	12.8	-
50% Def.	18.9	21.6	12.8	16.5	23.4	20.9	12.6	14.8
75% Def.	15.9	16.6	11.3	-	17.9	18.1	13.0	-
ER	30.3	25.6	28.9	31.0	30.4	25.0	27.8	24.0
ER + 50% Def.	24.4	23.5	30.6	28.8	29.8	27.5	26.1	21.0
LSD .05	2.4	3.0	2.5	2.7	3.2	4.3	2.7	2.4

Ear removal treatments affected the percent TNC differently as to stalk position. Ear removal increased the percent TNC of the top three nodes by 10 to 20 days after treatment, but not at the ear node, indicating the possibility of alternative sinks in the lower stalks and roots.

Stalk weight was expected to be altered by the imposed treatments, since the stalk can function as a large storage site for carbohydrate (Daynard et al., 1969; Hume and Campbell, 1973). Stalk weight was decreased by partial defoliation for most genotypes at all sampling intervals (Table 4). The exception was BSSS 133 where only the 75 percent level of defoliation decreased the stalk weight. Ear removal treatments caused an increase in stalk weight at all sampling intervals except for BSSS 56 and BSSS 133. For BSSS 133 no treatment increased stalk weight, and for BSSS 56 only ear removal increased the stalk weight.

The dry weight of leaves and leaf sheaths was expected to change as to treatment, since they, especially sheaths, can serve as temporary storage sites for carbohydrates. All treatments, except ear removal, decreased the weight of the leaves. Plants without ears were not different when compared to control plants. Sheath weight increased in plants without ears except for BSSS 133 by 10 to 20 days after treatment. Leaf removal decreased sheath weight only at the 75 percent level of defoliation.

Grain weight of control plants (Table 5) for both seasons ranged from very small with BSSS 133 to large with hybrids. Compared to the hybrids, the inbreds produced 7 percent (BSSS 133), 23 percent (BSSS 56), and 38 percent (BSSS114) as much grain. The grain weight and days to physio-

Table 4. Stalk weight (gm plant^{-1}) of maize plants as affected by treatment and genotype, both seasons

	Days after treatment			
	10	20	30	40
	gm plant^{-1}			
BSSS 56				
Control	93.9	90.9	79.9	-[a]
25% Def.	84.2	84.7	62.0	-
50% Def.	84.0	79.6	51.3	-
75% Def.	65.6	60.9	-	-
ER	111.8	120.7	-	-
ER + 50% Def.	96.1	98.3	-	-
LSD .05	6.4	9.4	12.1	
BSSS 114				
Control	84.7	78.6	74.6	-
25% Def.	77.3	67.0	56.4	-
50% Def.	76.7	65.2	55.4	-
75% Def.	72.5	57.2	-	-
ER	103.8	117.8	116.4	-
ER + 50% Def.	92.9	102.0	99.3	-
LSD .05	6.7	6.6	2.9	

[a]Treatment senesced or not sampled.

Table 4. (Continued)

	Days after treatment			
	10	20	30	40
	gm plant^{-1}			
BSSS 133				
Control	75.6	76.7	76.0	-
25% Def.	76.4	72.9	76.6	-
50% Def.	71.7	74.9	75.6	-
75% Def.	72.1	65.7	-	-
ER	81.6	80.4	-	-
ER + 50% Def.	73.2	76.0	-	-
LSD .05	6.9	5.7	5.7	
B73 X Mo17				
Control	139.6	140.5	141.7	119.5
25% Def.	130.0	119.2	97.6	94.0
50% Def.	122.4	108.5	77.0	97.6
75% Def.	106.8	87.1	-	-
ER	184.1	200.7	195.0	-
ER + 50% Def.	156.7	172.7	180.1	-
LSD .05	11.9	13.0	12.9	14.8

Table 4. (Continued)

	Days after treatment			
	10	20	30	40
	gm plant^{-1}			
Q97 X Q98				
Control	103.7	97.6	108.6	98.3
25% Def.	91.4	90.8	85.8	-
50% Def.	92.6	85.3	89.3	80.5
75% Def.	93.7	84.2	-	-
ER	146.7	148.3	166.9	122.1
ER + 50% Def.	135.2	133.7	157.4	116.9
LSD .05	8.1	6.7	12.9	10.3

logical maturity for control and defoliated plants were different between the two growing seasons. In 1979, grain weight increased (14 to 343 percent), and days to physiological maturity increased (21 to 55 percent), when compared to 1978. Larger grain weights in 1979 were possibly the result of a longer grain-filling period and a greater remobilization of dry matter from plant parts late in the growing season. Grain weight for both seasons was decreased by defoliation, especially the 75 percent level of defoliation. The 100-kernel weight also decreased with defoliation. BSSS 114 had the largest percentage decrease in 100-kernel weight among the genotypes. For Q97 X Q98 the two parameters had a larger percentage decrease in secondary ear weight when compared to the primary ear weight, indicating the stronger, sink strength of the primary ear (Bauman, 1960; Early et al., 1966).

There was little information in the literature to indicate how ear removal and/or partial defoliation would affect leaf senescence in maize. Leaf sensecence occurred differently among genotypes. With inbreds, 75 percent defoliation and both ear removal treatments decreased the time to leaf senescence. With hybrids, only 75 percent defoliation decreased the time to leaf senescence. None of the treatments delayed leaf senescence for the five genotypes used in this study. In 1979, leaf senescence for most genotypes occurred about 10 days earlier than in 1978, irregardless of treatment.

Concurrent with earlier senescence of leaves for most genotypes in 1979 was an increase in the days to physiological maturity and the grain

Table 5. Grain components (gm four plants^{-1}) for the grain weight and the 100-kernel weight for maize plants as affected by genotype and defoliation treatments, both seasons

	Primary grain weight	Secondary grain weight	Primary 100-kernel weight	Secondary 100-kernel weight
	gm four plants^{-1}			
BSSS 56				
Control	219.9	-[a]	23.6	-
25% Def.	225.4	-	25.0	-
50% Def.	203.5	-	25.4	-
75% Def.	162.4	-	20.8	-
LSD .05	34.9		3.2	-
BSSS 114				
Control	365.9	-	19.0	-
25% Def.	307.0	-	17.9	-
50% Def.	260.5	-	16.8	-
75% Def.	151.2	-	13.2	-
LSD .05	28.6		1.2	
BSSS 133				
Control	63.4	-	23.8	-
25% Def.	76.5	-	24.1	-
50% Def.	64.6	-	24.9	-
75% Def.	65.1	-	23.7	-
LSD .05	20.2		2.2	

[a]Treatment senesced or not sampled.

Table 5. (Continued)

	Primary grain weight	Secondary grain weight	Primary 100-kernel weight	Secondary 100-kernel weight
	gm four plants^{-1}			
B73 X Mo17				
Control	942.1	-	34.3	-
25% Def.	739.1	-	29.1	-
50% Def.	602.3	-	25.3	-
75% Def.	382.4	-	17.3	-
LSD .05	12.1		2.9	
Q97 X Q98				
Control	595.4	392.6	27.7	24.1
25% Def.	471.9	224.1	22.7	18.6
50% Def.	441.4	198.6	21.8	16.9
75% Def.	253.8	41.5	18.5	5.9
LSD .05	33.7	59.5	2.2	2.4

weight. The percent TNC of the stalk was probably remobilized by a greater than normal level, since no current photosynthate was available for grain-filling during this period.

Plants without ears exhibited a purple discoloration along the midrib and leaf margins similar to observations by Moss (1962) and Allison and Weinmann (1970). There was less purple discoloration with ear removal plus 50 percent defoliation than with ear removal and no defoliation.

DISCUSSION

The inbreds used in this study were chosen from the Iowa Stiff Stalk selection for possible differences in sink strengths. Photosynthetic studies of 100 inbreds indicated no difference in ranking of CER whether measured during vegetative or grain-filling stage. However, two exceptions were observed. Inbred BSSS 133 had average CER levels during the vegetative stage, but was relatively much lower during grain-filling, while BSSS 56 showed a similar but less pronounced trend. BSSS 114 was more representative of the majority of Iowa Stiff Stalk Synthetic inbreds. In previous studies of several inbreds, only BSSS 133 and BSSS 56 showed an increase in CER due to defoliation with BSSS 133 showing the greatest response (R. B. Pearce, unpublished research, Dept. of Agronomy, Iowa State University).

An estimate of the relative source-sink ratio of the genotypes (Table 6) was determined from the data. The potential CER of plants was estimated by taking the average CER of both leaf positions at 10 days after treatment for 50 percent and 75 percent defoliation. This value was multiplied by leaf area to estimate source strength of the plant. Sink strength was estimated by adding the grain weight of controls to 50 percent of the stalk weight of plants without ears. The 50 percent value was used because the increase in stalk weight between plants with 75 percent defoliation and plants without ears fluctuated from 47 to 53 percent among genotypes. The potential source strength was divided by sink strength to derive a source-sink ratio. This ratio was then divided by the lowest ratio (BSSS 114) to

Table 6. Estimations of relative source and sink strengths for the development of source-sink ratios. The ratios were averaged over both seasons

	Potential CER[a]	Leaf area[b] (LA)	Potential source strength (CER x LA)
	(mg CO_2 $dm^{-2}hr^{-1}$)	(dm^2 $plant^{-1}$)	(mg CO_2 hr^{-1} $plant^{-1}$)
BSSS 133	22.6	2308.4	52,169.8
BSSS 56	33.1	2337.4	77,367.9
BSSS 114	16.3	2111.2	34,412.6
B73 x Mo17	44.5	3259.6	145,052.2
Q97 x Q98	40.5	3625.0	146,812.5

[a] The average CER of both leaf positions at 10 days after treatment for 50% and 75% defoliation to avoid feedback inhibition on CER.

[b] Leaf area of controls estimated by multiplying leaf weight by an average specific leaf weight of 0.058 mg dm^{-2}.

[c] Contribution of stalk estimated by multiplying stalk weight of plants without ears by 50 percent. The 50 percent value was chosen because it was the average difference in stalk weight between the ear removal treatment and the 75% defoliation treatment.

	Grain weight (gm plant^{-1})	Est. of[c] contribution of stalk (gm plant^{-1})	Sink strength (gm plant^{-1})	Relative source-sink ratio
BSSS 133	15.9	40.8	56.7	3.8
BSSS 56	55.0	55.9	110.9	2.9
BSSS 114	91.5	51.9	143.4	1.0
B73 x Mo17	235.5	92.1	327.6	1.8
Q97 x Q98	247.0	73.4	320.4	1.9

derive relative, source-sink ratios. The source-sink ratios did not take time for grain filling or the decrease in CER with time into account, and are only rough estimates.

Differences in leaf area and CER were responsible for the range in source strengths observed with the genotypes. The leaf areas for inbreds were similar, but the hybrids had about 50 percent more leaf area per plant. The CER ranged from very low with BSSS 114 to high with the hybrids. The differences in CER among inbreds were the main reason why BSSS 114 had such low source strength. Hybrids had large source strengths compared to inbreds due to both CER and leaf area.

Sink strength ranged from very low with BSSS 133 to high with hybrids. For BSSS 133, both grain weight and stalk weight were low, and accounted for the low sink strength. Sink strength for BSSS 56 was also low, but was mainly due to less grain weight than BSSS 114. The grain weight and number of kernels per ear among inbreds were the largest with BSSS 114 which was surprising because of low source strength and low 100-kernel weight. If BSSS 114 had a greater source strength, its grain weight might have been about 50 percent higher if it has the capability for kernel weight equal to the other inbreds. These data indicate that BSSS 114 is source limited. The hybrids had the greatest sink strength because of larger stalks and ears. The capacity of hybrid stalks to store TNC was very large when compared to inbreds which had similar stalk weights and TNC levels.

The large capacity for stalk storage has the advantage of storing excess TNC when the source-sink ratio is high and remobilizing the TNC to

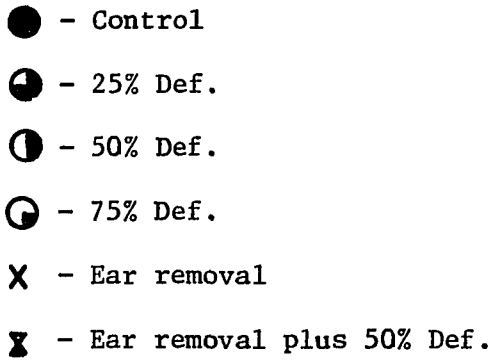
other sinks when the source-sink ratio became low (Figure 3). A reduced source-sink ratio could be caused by reduced photosynthesis or increased sink demand in areas such as the ear.

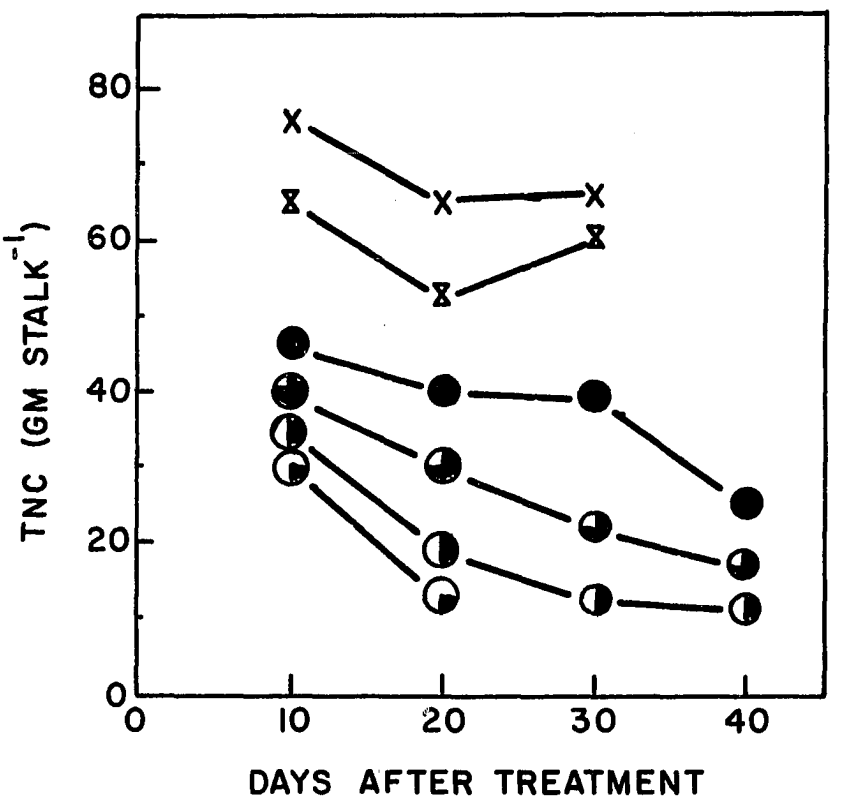
When genotypes had a large source-sink ratio, as with BSSS 56 and BSSS 133, then the CER of both leaf positions was increased by defoliation. Both genotypes had much more potential source strength than was needed to fill the grain and the stalk which resulted in feedback inhibition. Of the two, BSSS 133 had a larger increase in CER after defoliation and the largest source-sink ratio. The very low kernel number for BSSS 133 was the reason that this inbred was sink limited, and that defoliation reduced the source-sink ratio so that feedback inhibition was less prominant or non-existant.

Increasing the source-sink ratio by ear removal caused plants with small source-sink ratios to quickly fill alternative sinks (primarily stalks) with stored compounds. Filling the stalk reduced sink demand and leaf CER was reduced due to feedback inhibition. However, there is quite a large capacity for TNC storage in the stalk. This capacity may account for the six to 12 days necessary for CER to decline due to ear removal observed in Part I of this dissertation.

Estimating sink strength by using grain weight of controls may cause an underestimation of potential sink strength. Even after pollination there is kernel abortion or, if abortion does not occur and the source cannot produce enough photosynthate, kernel weight may be reduced. Inbred BSSS 114 had much lighter kernels than the other genotype. If it has the potential to fill the kernels to the same weight as other genotypes, then

Figure 3. Total nonstructural carbohydrates (TNC) of the stalk (gm stalk $^{-1}$) at each sampling interval for B73 X Mo17 as affected by treatment, both seasons




80
60
40
20
0
0
10
20
30
40
TNC (GM STALK^{-1})
DAYS AFTER TREATMENT

its estimated sink strength was underestimated. However, if other genotypes had excessive kernel abortion which might have been reduced by increased photosynthate availability, then their estimated sink strength was also underestimated. Ear removal plus 50 percent defoliation altered the source-sink ratio found in plants without ears, and the decline in CER via feedback inhibition for BSSS 114 and B73 X Mo17 was not as pronounced. Neither leaf position for BSSS 56 and BSSS 133, and the ear leaf for Q97 X Q98, had CER decreased, possibly because the TNC level in the stalk was not large enough for feedback inhibition to occur. Although the source-sink ratio for BSSS 56 was large enough for defoliation to increase CER, it was also small enough for ear removal, but not ear removal plus 50 percent defoliation, to reduce CER. It would be of interest to know how small the source-sink ratio must be before ear removal treatments reduce CER.

These experiments showed that under field conditions leaf CER was changed by the imposed treatments only when the genotype had a certain source-sink ratio. The capacity of the stalk to store and/or remobilize TNC seemed to be very important in the control of the realized rate of CER.

SUMMARY AND CONCLUSIONS

Studies were undertaken to investigate the short- and long-term effects of altering the source-sink ratio on selected genotypes. Five maize genotypes were selected based on previously observed responses to defoliation and/or ear removal (R. B. Pearce, unpublished research, Dept. of Agronomy, Iowa State University).

The first study investigated the short-term effects of ear removal and/or 50 percent defoliation with field-grown maize hybrids. Leaf CER, leaf TNC, and stalk TNC were measured every one to three days during the nine- to 15-day period after ear removal.

Leaf position was more significant than genotype in determining the effect of ear removal. Five to 12 days elapsed before the second leaf decreased via feedback inhibition in CER. The CER of the ear leaf was slightly decreased by ear removal on a few sampling dates, but this decrease was not as apparent or significant as with the second leaf. Removing ears plus 50 percent of the leaves caused the CER of both leaf positions to be intermediate between control plants and plants with ears removed. The data indicate the possibility of the stalk being an alternative sink to the ear. The TNC of ear leaf and stalk were not found to be sensitive measurements of the changes that occurred in leaf CER.

The second study compared the long-term effects of altering the source-sink ratio with five maize genotypes for two growing seasons. Leaf CER, stalk TNC, and the dry weights of the leaves, sheaths, stalk, and ears were measured at 10-day intervals following source and/or sink manipulation.

Grain and cob weights, 100-kernel weight, and the days to physiological maturity were also measured with defoliated plants.

The CER of both leaf positions was altered by 10 days after treatment. The relative source-sink ratio of the genotypes was the most important factor in determining how the imposed treatments affected leaf CER. If the genotype had a large source-sink ratio, as with BSSS 56 and BSSS 133, then leaf CER was increased by defoliation. When ears were removed, leaf CER decreased via feedback inhibition only if the relative source-sink ratio of the genotype was smaller. All genotypes, except BSSS 133, had CER decreased. Leaf CER of plants without ears plus 50 percent of their leaves decreased only in genotypes which had large estimated sink size. The CER decline was not as much when compared to plants without ears, possibly because the increased level of assimilate stored in the stalk was still insufficient to produce the full affect of feedback inhibition on CER. None of the treatments delayed leaf senescence. In 1979 leaves senesced about 10 days earlier than 1978.

The other parameters measured in this study also changed following defoliation and/or ear removal. The weights of the stalk, leaves, sheaths, and ears decreased after defoliation as did stalk TNC. Ear removal increased the dry matter parameters except the weight of the leaves, and the TNC of the top three nodes. The TNC of the ear node was not changed by ear removal treatments, indicating the possibility of alternative sinks in the lower stalk. Ear removal plus 50 percent defoliation decreased the weight of the leaves and sheaths, but increased the stalk weight and the

TNC of the top three nodes. The stalk was the most important, measured parameter correlated to the realized rate of CER.

The harvest parameters elucidated how defoliation affects grain yield. The cob and grain weights, 100-kernel weight, and the days to physiological maturity were decreased by defoliation, especially with 75 percent defoliation. The remobilization of carbohydrates stored in the various plant parts was not capable of maintaining grain weight, even if leaf CER was increased. Grain weight and days to physiological maturity were increased in 1979. A greater than normal remobilization of TNC stored in the stalk may have occurred during the extended grain-filling period, since leaves had already senesced.

LITERATURE CITED

Allison, J. C. S., and D. J. Watson. 1966. The production and distribution of dry matter in maize after flowering. Ann. Bot. 30: 365-381.

Allison, J. C. S., and H. Weinmann. 1970. Effect of absence of developing grain on carbohydrate content and senescence of maize leaves. Plant Physiol. 46: 435-436.

Austin, R. B. 1972. Diurnal changes in the sugar and organic anion concentrations in red beet leaves. Ann. Bot. 36: 475-483.

Austin, R. B., and J. Edrich. 1975. Effects of ear removal on photosynthesis, carbohydrate accumulation and on the distribution of assimilated ^{14}C in wheat. Ann. Bot. 39: 141-152.

Bauman, L. P. 1960. Relative yields of first (apical) and second ears of semi-prolific southern corn hybrids. Agron. J. 52: 220-222.

Birecka, H., and L. Dakic-Wlodkowska. 1963. Photosynthesis, translocation and accumulation of assimilates in cereals during grain development. III. Spring wheat photosynthesis and the daily accumulation of photosynthates in the grain. Acta Soc. Bot. Pol. 32: 631-650.

Burt, R. L. 1964. Carbohydrate utilization as a factor in plant growth. Aust. J. Biol. Sci. 17: 867-877.

Chatterton, N. J., and J. E. Silvius. 1979. Photosynthate partitioning into starch in soybean leaves. I. Effects of photoperiod versus photosynthetic period duration. Plant Physiol. 64: 749-753.

Chatterton, N. J., G. E. Carlson, W. E. Hungerford, and D. R. Lee. 1972. Effect of tillering and cool nights on photosynthesis and chloroplast starch in pangola. Crop Sci. 12: 206-208.

Christy, A. L., and C. A. Swanson. 1976. Control of translocation by photosynthesis and carbohydrate concentration of the source leaf. p. 329-346. In I. F. Wardlaw and J. P. Passioura (eds.) Transport and transfer processes in plants. Academic Press, New York.

Ciha, A. J., and W. A. Brun. 1978. Effect of pod removal on nonstructural carbohydrate concentration in soybean tissue. Crop Sci. 18: 773-776.

Claussen, W., and E. Biller. 1977. Die Bedeutung der Saccharose- und Stärkegehalte der Blätter für die Regulierung der Netto-Photosntheseraten. Z. Pflanzenphysiol. Bd. 81: 189-198.

Criswell, J. G., and R. M. Shibles. 1972. Influence of sink-source on flag-leaf net photosynthesis in oats. Iowa State J. Res. 46: 405-415.

Crookston, R. K., J. O'Toole, R. Lee, J. L. Ozbun, and D. H. Wallace. 1974. Photosynthetic depression in beans after exposure to cold for one night. Crop Sci. 14: 457-464.

Daynard, T. B., J. W. Tanner, and D. J. Hume. 1969. Contribution of stalk soluble carbohydrates to grain yield in corn (Zea mays L.). Crop Sci. 9: 831-834.

Early, E. B., R. J. Miller, G. L. Reichert, R. H. Hageman, and R. D. Seif. 1966. Effects of shade on maize production under field conditions. Crop Sci. 6: 1-7.

Eastin, J. A. 1969. Leaf position and leaf function in corn carbon-14 labeled photosynthate distribution in corn in relation to leaf position and function. p. 81-89. In J. Sutherland and R. J. Falasca (eds.). Proceedings of the 24th Annual Corn and Sorghum Research Conference. American Seed Association, Washington, D.C.

Haapala, H. 1969. Photosynthesis and starch metabolism of chloroplasts during prolonged illumination. Planta 86: 259-266.

Habeshaw, D. 1973. Translocation and the control of photosynthesis in sugar beet. Planta 110: 213-226.

Hall, A. J., and F. L. Milthorpe. 1978. Assimilate source-sink relationships in Capsicum annuum L. III. The effects of fruit excision on photosynthesis and leaf and stem carbohydrates. Aust. J. Plant Physiol. 5: 1-13.

Hanway, J. J., and W. A. Russell. 1969. Dry-matter accumulation in corn (Zea mays L.) plants: Comparison among single-cross hybrids. Agron. J. 61: 947-951.

Hartt, C. E. 1965. Light and translocation of C^{14} in detached blades of sugarcane. Plant Physiol. 40: 718-724.

Hartt, C. E., and H. P. Kortschak. 1964. Sugar gradients and translocation of sucrose in detached blades of sugarcane. Plant Physiol. 39: 460-474.

Hartt, C. E., H. P. Kortschak, and G. O. Burr. 1964. Effects of defoliation, deradication, and darkening the blade upon translocation of C^{14} in sugarcane. Plant Physiol. 39: 15-22.

Hartt, C. E., H. P. Kortschak, A. J. Forbes, and G. O. Burr. 1963. Translocation of C^{14} in sugarcane. Plant Physiol. 38: 305-318.

Hesketh, J. D., and D. N. Moss. 1963. Variation in the response of photosynthesis to light. Crop Sci. 3: 107-110.

Hodgkinson, K. C. 1974. Influence of partial defoliation on photosynthesis, photorespiration and transpiration by lucerne leaves of different ages. Aust. J. Plant Physiol. 1: 561-578.

Hopkinson, J. M. 1966. Studies on the expansion of the leaf surface. VI. Senescence and the usefulness of old leaves. J. Exp. Bot. 17: 762-770.

Hume, D. J., and D. K. Campbell. 1973. Distribution and utilization of ^{14}C-labeled assimilates in soybeans. Crop Sci. 13: 519-524.

Khan, A., and G. R. Sagar. 1969. Alteration of the pattern of distribution of photosynthetic products in the tomato by manipulation of the plant. Ann. Bot. 33: 753-762.

Kiesselbach, T. A. 1948. Endosperm type as a physiological factor in corn yields. J. Amer. Soc. Agron. 40: 216-236.

King, R. W., I. F. Wardlaw, and L. T. Evans. 1967. Effect of assimilate utilization on photosynthetic rate in wheat. Planta 77: 261-276.

Kollman, G. E., J. G. Streeter, D. L. Jeffers, and R. B. Curry. 1974. Accumulation and distribution of mineral nutrients, carbohydrate, and dry matter in soybean plants as influenced by reproductive sink size. Agron. J. 66: 549-554.

Kriedemann, P. E., B. R. Loveys, J. Possingham, and M. Satoh. 1976. Sink effects on stomatal physiology and photosynthesis. p. 401-414. In I. F. Wardlaw and J. B. Passioura (eds.) Transport and transfer processes in plants. Academic Press, New York.

Leopold, A. C. 1961. Senescence in plant development. The death of plants or plant parts may be a positive ecological or physiological value. Science 134: 1727-1732.

Leopold, A. C., E. Niedergang-Kamien, J. Janick. 1959. Experimental modification of plant senescence. Plant Physiol. 34: 570-573.

Maggs, D. H. 1964. Growth rates in relation to assimilate supply and demand. I. Leaves and roots as limiting regions. J. Exp. Bot. 15: 574-583.

Mondal, M. H., W. A. Brun, and M. L. Brenner. 1978. Effects of sink removal on photosynthesis and senescence in leaves of soybean (Glycine max L.) plants. Plant Physiol. 61: 394-397.

Moorby, J., and F. L. Milthorpe. 1975. Potato. p. 225-258. In L. T. Evans (ed.). Crop Physiology. Cambridge University Press, Cambridge.

Moss, D. N. 1962. Photosynthesis and barrenness. Crop Sci. 2: 366-367.

Nafziger, E. D., and H. R. Koller. 1976. Influence of leaf starch concentrations of CO_2 assimilation in soybean. Plant Physiol. 57: 560-563.

Nelson, N. 1944. A photometric adaptation of the Somogyi method for the determination of glucose. J. Biol. Chem. 153: 375-380.

Nosberger, J., and E. C. Humphries. 1965. The influence of removing tubers on dry-matter production and net assimilation rate of potato plants. Ann. Bot. 29: 579-588.

Patterson, T. G., and W. A. Brun. 1980. Influence of sink removal in the senescence pattern of wheat. Crop Sci. 20: 19-23.

Pearce, R. B., T. M. Crosbie, and J. J. Mock. 1976. A rapid method for measuring the net photosynthesis of excised leaves by using air-sealed chambers. Iowa State J. Res. 51: 25-33.

Petrie, A. H. K., R. Watson, and E. D. Ward. 1939. Physiological ontogeny in the tobacco plant. I. The drifts in dry weight and leaf area in relation to phosphorus supply and topping. Aust. J. Exp. Biol. Med. Sci. 17: 93-122.

Rawson, H. M., R. M. Gifford, and P. M. Bremner. 1976. Carbon dioxide exchange in relation to sink demand in wheat. Planta 132: 19-23.

Sanders, T. H., D. A. Ashley, and R. H. Brown. 1977. Effects of partial defoliation on petiole phloem area, photosynthesis, and ^{14}C translocation in developing soybean leaves. Crop Sci. 17: 548-550.

Sayre, J. D., V. H. Morris, and F. D. Richey. 1931. The effect of preventing fruiting and reducing the leaf area on the accumulation of sugars in the corn stem. Agron. J. 23: 751-753.

Somogyi, M. 1945. A new reagent for the determination of sugars. J. Biol. Chem. 160: 61-68.

Swanson, C. A., J. Hoddinott, and J. W. Sij. 1976. The effect of selected leaf parameters on translocation rates. p. 347-356. In I. F. Wardlaw

and J. B. Passioura (eds.) Transport and transfer processes in plants. Academic Press, New York.

Sweet, G. B., and P. F. Wareing. 1966. Role of plant growth in regulating photosynthesis. Nature 210: 77-79.

Thorne, J. H. 1979. Assimilate redistribution from soybean pod walls during seed development. Agron. J. 71: 812-816.

Thorne, J. H., and H. R. Koller. 1974. Influence of assimilate demand on photosynthesis, diffusive resistances, translocation, and carbohydrate levels of soybean leaves. Plant Physiol. 54: 201-207.

Troughton, J. H. 1976. Translocation in Zea mays leaves. p. 339-346. In I. F. Wardlaw and J. B. Passioura (eds.) Transport and transfer processes in plants. Academic Press, New York.

Upmeyer, D. J., and H. R. Koller. 1973. Diurnal trends in net photosynthetic rate and carbohydrate levels of soybean leaves. Plant Physiol. 51: 851-857.

Wardlaw, I. F. 1976. Assimilate partitioning: Cause and effect. p. 381-392. In I. F. Wardlaw and J. B. Passioura (eds.) Transport and transfer processes in plants. Academic Press, New York.

Wareing, P. F., M. M. Khalifa, and K. J. Treharne. 1968. Rate-limiting processes in photosynthesis at saturating light intensities. Nature 220: 453-457.

Zelitch, I. 1979. Photosynthesis and plant productivity. Chemical and Engineering News 57: 28-48.

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APPENDIX

Table A1. Carbon dioxide exchange rates (mg CO_2 dm^{-2} hr^{-1}) of the second leaf from the tassel and the ear leaf at each collection of field-grown single plants for B73 X Mo17, 1978 season

	Second leaf from the tassel										Ear leaf									
	Days after ear removal										Days after ear removal									
	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9
	mg CO_2 dm^{-2} hr^{-1}																			
Control	40	32	37	35	31	44	33	22	34	21	38	34	41	40	31	40	39	30	44	23
ER	43	26	33	32	29	35	23	16	15	6	44	29	35	36	26	35	28	24	26	13
ER + 50% Def.	44	25	34	32	35	30	21	20	27	18	40	33	37	35	28	41	31	28	28	17
LSD .05	9	7	10	5	11	15	5	8	12	13	9	11	11	7	9	11	8	7	9	11

Table A2. Carbon dioxide exchange rates (mg CO_2 $dm^{-2}hr^{-1}$) of the second leaf from the tassel and the ear leaf at each collection of field-grown single plants of maize genotypes; expressed as the mean of four replications, 1979 season

	Second leaf from the tassel						Ear leaf					
	--Days after ear removal--						Days after ear removal					
	0	3	6	9	12	15	0	3	6	9	12	15
	----------mg CO_2 $dm^{-2}hr^{-1}$----------											
B73 X Mo17												
Control	43	48	45	30	49	54	41	42	40	48	48	52
ER	31	35	43	23	16	1	40	40	44	34	36	32
ER + 50% Def.	30	46	42	33	35	31	35	41	44	39	43	38
LSD .05	19	11	11	15	12	11	9	21	11	9	12	19
Q97 X Q98												
Control	46	52	61	46	50	45	44	55	52	51	46	49
ER	34	62	44	16	32	3	44	53	54	49	48	48
ER + 50% Def.	46	52	54	30	41	38	46	61	58	24	44	45
LSD .05	17	15	12	13	7	16	14	13	5	10	10	11
BSSS 114												
Control	22	18	14	22	16	19	25	15	20	20	16	16
ER	28	20	18	19	17	17	25	19	19	20	16	19
ER + 50% Def.	29	18	20	17	18	14	25	21	18	15	16	20
LSD .05	7	6	7	7	5	8	3	8	6	6	6	3

Table A3. The %TNC (mg glucose equiv./100 mg sample) of a bulk sample of the top three nodes and and the singular ear node at each collection of field-grown single plants of B73 X Mo17; expressed as the mean of four replications, 1978 season

	Top three nodes										Ear node									
	Days after ear removal										Days after ear removal									
	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9
	%TNC(mg glucose equiv./ 100mg sample)																			
Control	29	26	30	41	39	37	31	28	28	29	25	38	38	42	38	47	35	32	36	25
ER	29	29	28	38	41	43	33	27	35	24	31	28	33	42	38	37	34	31	32	27
ER + 50% Def.	27	30	33	35	40	34	34	33	28	27	33	33	31	38	45	42	41	37	31	26
LSD .05	5	5	6	4	7	9	7	5	5	4	8	5	5	7	7	7	11	2	2	4

Table A4. The %TNC (mg glucose equiv./100 mg sample) of the top three nodes, the singular ear node, and the ear leaf at each collection of field-grown single plants of maize genotypes; expressed as the mean of four replications, 1979 season

	Days after ear removal					
	0	3	6	9	12	15
	%TNC(mg glucose equiv./100 mg sample)					
	Top Three Nodes					
B73 X Mo17						
Control	36	30	34	26	32	31
ER	32	36	32	34	36	39
ER + 50% Def.	32	31	29	37	30	43
LSD .05	2	4	3	7	7	6
BSSS 114						
Control	45	47	50	48	47	41
ER	43	49	51	54	49	45
ER + 50% Def.	46	49	47	47	44	44
LSD .05	7	7	8	3	7	5
Q97 X Q98						
Control	34	32	38	30	45	42
ER	28	33	38	38	54	51
ER + 50% Def.	37	38	43	49	52	44
LSD .05	13	4	11	7	7	3

Table A4. (Continued)

	Days after ear removal					
	0	3	6	9	12	15
	%TNC(mg glucose equiv./100 mg sample)					
	Ear Node					
B73 X Mo17						
Control	38	34	34	31	41	31
ER	38	41	32	39	42	42
ER + 50% Def.	34	35	32	45	39	46
LSD .05	6	5	7	4	4	8
BSSS 114						
Control	45	43	47	46	50	45
ER	49	50	49	50	49	51
ER + 50% Def.	46	49	47	47	46	43
LSD .05	5	5	4	4	7	7
Q97 X Q98						
Control	29	32	45	29	46	48
ER	39	33	43	37	56	47
ER + 50% Def.	35	36	46	53	52	49
LSD .05	8	6	7	12	5	8

Table A4. (Continued)

	Days after ear removal					
	0	3	6	9	12	15
	%TNC(mg glucose equiv./100 mg sample)					
	Ear Leaf					
B73 X Mo17						
Control	24	23	22	19	16	20
ER	26	28	30	26	24	26
ER + 50% Def.	25	25	21	23	17	27
LSD .05	3	7	10	6	5	9
BSSS 114						
Control	20	15	14	13	17	13
ER	20	16	14	14	17	16
ER + 50% Def.	15	14	13	13	15	12
LSD .05	5	3	3	3	5	5
Q97 X Q98						
Control	19	18	16	14	13	23
ER	20	20	16	22	19	25
ER + 50% Def.	21	18	17	26	18	20
LSD .05	8	4	4	8	5	13

Table A5. Carbon dioxide exchange rates (mg CO_2 $dm^{-2}hr^{-1}$) of the second leaf from the tassel and the ear leaf at each collection of field-grown single plants of maize genotypes; expressed as the mean of eight replications, 1978 season

	Second leaf from the tassel				Ear leaf			
	----Days after treatment----				----Days after treatment----			
	10	20	30	40	10	20	30	40
	----------mg CO_2 $dm^{-2}hr^{-1}$----------							
BSSS 56								
Control	28	14	13	- [a]	29	19	5	-
25% Def.	36	23	3	-	33	22	5	-
50% Def.	37	25	5	-	31	23	8	-
75% Def.	40	18	-	-	36	18	-	-
ER	14	7	-	-	20	8	-	-
ER + 50% Def.	32	9	-	-	22	14	-	-
LSD .05	7	6	6		4	7	8	
BSSS 114								
Control	19	12	7	-	16	11	10	-
25% Def.	18	7	3	-	18	10	1	-
50% Def.	21	10	4	-	17	11	2	-
75% Def.	16	8	-	-	18	7	-	-
ER	14	2	-	-	14	7	-	-
ER + 50% Def.	16	6	-	-	14	9	-	-
LSD .05	4	4	4		3	3	3	

[a] Treatment senesced or not sampled.

Table A5. (Continued)

	Second leaf from the tassel				Ear leaf			
	----Days after treatment---				----Days after treatment--			
	10	20	30	40	10	20	30	40
	----------mg CO_2 $dm^{-2}hr^{-1}$----------							
BSSS 133								
Control	9	6	3	-	20	10	3	-
25% Def.	15	14	4	-	18	12	9	-
50% Def.	19	4	3	-	23	20	9	-
75% Def.	23	13	-	-	26	20	-	-
ER	6	3	-	-	15	9	-	-
ER + 50% Def.	13	7	-	-	19	6	-	-
LSD .05	6	5	3		6	7	6	
B73 X Mo17								
Control	33	38	27	8	41	37	35	21
25% Def.	32	37	29	11	40	37	34	21
50% Def.	30	36	30	8	37	41	37	9
75% Def.	36	35	-	-	42	39	-	-
ER	17	5	2	-	24	14	6	-
ER + 50% Def.	17	7	2	-	28	19	6	-
LSD .05	7	6	4	8	7	6	5	8

Table A5. (Continued)

	Second leaf from the tassel				Ear leaf			
	----Days after treatment---				----Days after treatment---			
	10	20	30	40	10	20	30	40
	----------mg $CO_2 dm^{-2} hr^{-1}$----------							
Q97 X Q98								
Control	41	30	25	11	37	36	29	20
25% Def.	42	33	22	-	40	35	26	-
50% Def.	40	29	21	8	38	34	31	6
75% Def.	42	31	-	-	43	38	-	-
ER	27	14	15	3	32	21	24	25
ER + 50% Def.	34	30	21	10	39	37	31	22
LSD .05	5	5	6	6	5	6	6	12

Table A6. Carbon dioxide exchange rates (mg CO_2 $dm^{-2}hr^{-1}$) of the second leaf from the tassel and the ear leaf at each collection of field-grown single plants of maize genotypes; expressed as the mean of eight replications, 1979 season

	Second leaf from the tassel				Ear leaf			
	----Days after treatment----				----Days after treatment----			
	10	20	30	40	10	20	30	40
	----------mg CO_2 $dm^{-2}hr^{-1}$----------							
BSSS 56								
Control	31	25	9	-[a]	25	21	10	-
25% Def.	36	30	-	-	31	22	-	-
50% Def.	30	29	-	-	30	24	-	-
75% Def.	34	32	-	-	28	25	-	-
ER	21	17	-	-	21	20	-	-
ER + 50% Def.	28	30	-	-	25	19	-	-
LSD .05	7	6			5	5		
BSSS 114								
Control	15	15	5	-	19	14	6	-
25% Def.	17	15	-	-	14	12	-	-
50% Def.	14	13	-	-	17	14	-	-
75% Def.	13	8	-	-	14	11	-	-
ER	13	4	.3	-	13	10	1	-
ER + 50% Def.	11	13	5	-	12	9	4	-
LSD .05	3	1	2		3	3	2	

[a]Treatment senesced or not sampled.

Table A6. (Continued)

	Second leaf from the tassel				Ear leaf			
	----Days after treatment---				----Days after treatment--			
	10	20	30	40	10	20	30	40
	----------mg CO_2 $dm^{-2}hr^{-1}$----------							
BSSS 133								
Control	15	10	-	-	22	17	-	-
25% Def.	24	21	-	-	17	23	-	-
50% Def.	25	16	-	-	25	26	-	-
75% Def.	26	24	-	-	22	23	-	-
ER	24	8	-	-	20	15	-	-
ER + 50% Def.	18	11	-	-	15	16	-	-
LSD .05	5	6			7	4		
B73 X Mo17								
Control	47	42	15	-	50	44	21	-
25% Def.	55	43	19	-	53	41	22	-
50% Def.	53	49	-	-	52	41	-	-
75% Def.	55	20	-	-	52	30	-	-
ER	38	26	.3	-	42	27	7	-
ER + 50% Def.	51	29	1	-	40	26	10	-
LSD .05	8	11	3		7	11	5	

Table A6. (Continued)

	Second leaf from the tassel				Ear leaf			
	----Days after treatment---				----Days after treatment---			
	10	20	30	40	10	20	30	40
	----------mg CO_2 $dm^{-2}hr^{-1}$----------							
Q97 X Q98								
Control	47	43	26	-	42	40	30	-
25% Def.	40	38	-	-	41	42	-	-
50% Def.	44	43	5	-	40	42	6	-
75% Def.	33	35	-	-	44	30	-	-
ER	42	13	2	-	37	46	37	-
ER + 50% Def.	40	37	21	-	41	39	37	-
LSD .05	7	9	7		2	10	8	

Table A7. The %TNC (mg glucose equiv./100 mg sample) of a bulk sample of the top three nodes and the singular ear node at each collection of field-grown single plants of maize genotypes; expressed as the mean of eight replications, 1978 season

	Top three nodes				Ear node			
	----Days after treatment----				----Days after treatment----			
	10	20	30	40	10	20	30	40
	-------%TNC (mg glucose equiv./100 mg sample)----------							
BSSS 56								
Control	23	32	15	-[a]	35	37	15	-
25% Def.	33	29	13	-	34	36	13	-
50% Def.	31	24	17	-	25	29	17	-
75% Def.	21	14	-	-	21	18	-	-
ER	28	34	-	-	29	38	-	-
ER + 50% Def.	41	27	-	-	47	35	-	-
LSD .05	6	6	5		6	4	5	
BSSS 114								
Control	27	30	29	-	30	29	28	-
25% Def.	32	38	29	-	33	34	29	-
50% Def.	34	25	23	-	33	23	22	-
75% Def.	30	25	-	-	29	20	-	-
ER	40	32	33	-	34	34	30	-
ER + 50% Def.	32	30	30	-	36	32	32	-
LSD .05	5	13	6		2	5	6	

[a]Treatment senesced or not sampled.

Table A7. (Continued)

	Top three nodes				Ear node			
	----Days after treatment----				----Days after treatment----			
	10	20	30	40	10	20	30	40
	----------%TNC (mg glucose equiv./100 mg sample)-------							
BSSS 133								
Control	31	33	33	-	24	33	30	-
25% Def.	31	16	31	-	35	24	32	-
50% Def.	34	42	-	-	37	36	26	-
75% Def.	24	45	-	-	34	39	-	-
ER	36	43	-	-	33	34	-	-
ER + 50% Def.	34	39	-	-	33	36	-	-
LSD .05	5	3	4		4	4	3	
B73 X Mo17								
Control	33	25	21	19	42	31	26	14
25% Def.	28	25	14	15	36	29	20	20
50% Def.	22	17	13	6	32	24	18	16
75% Def.	34	18	9	-	21	17	12	-
ER	30	33	23	-	39	30	23	-
ER + 50% Def.	47	30	17	-	25	31	17	-
LSD .05	7	3	3	4	6	4	5	3

Table A7. (Continued)

	Top three nodes				Ear node			
	----Days after treatment----				----Days after treatment----			
	10	20	30	40	10	20	30	40
	----------%TNC (mg glucose equiv./ 100 mg sample)---------							
Q97 X Q98								
Control	22	20	26	20	23	33	24	13
25% Def.	20	15	13	-	21	13	13	-
50% Def.	20	14	12	17	22	15	11	15
75% Def.	14	13	11	-	16	15	13	-
ER	27	31	26	31	35	27	28	24
ER + 50% Def.	23	32	27	29	30	35	25	21
LSD .05	3	3	3	4	5	4	5	3

Table A8. The %TNC (mg glucose equiv./100 mg sample) of a bulk sample of the top three nodes and the singular ear node at each collection of field-grown single plants of maize genotypes; expressed as the mean of eight replications, 1979 season [a]

	Top three nodes				Ear node			
	----Days after treatment----				----Days after treatment----			
	10	20	30	40	10	20	30	40
	----------%TNC (mg glucose equiv./100 mg sample)----------							
BSSS 114								
Control	23	34	29	-[b]	25	27	26	-
25% Def.	23	23	25	-	30	27	22	-
50% Def.	22	23	19	-	23	23	19	-
75% Def.	20	22	-	-	25	11	-	-
ER	35	34	37	-	33	26	37	-
ER + 50% Def.	36	31	40	-	34	29	40	-
LSD .05	5	6	4		3	7	2	
B73 X Mo17								
Control	26	28	25	24	32	35	38	28
25% Def.	29	21	24	-	30	27	32	-
50% Def.	29	14	-	-	30	17	-	-
75% Def.	31	15	-	-	27	8	-	-
ER	45	30	44	-	50	33	41	-
ER + 50% Def.	47	27	43	-	47	31	49	-
LSD .05	7	5	5		6	6	4	

[a]The samples for BSSS 56 and BSSS 133 were inadvertently destroyed.

[b]Treatment senesced or not sampled.

Table A8. (Continued)

	Top three nodes				Ear node			
	----Days after treatment----				----Days after treatment----			
	10	20	30	40	10	20	30	40
	----------%TNC (mg glucose equiv./100 mg sample)-------							
Q97 X Q98								
Control	23	19	21	22	34	21	31	22
25% Def.	17	17	-	-	21	16	-	-
50% Def.	18	29	14	-	23	27	14	-
75% Def.	18	21	-	-	20	22	-	-
ER	34	20	32	-	26	23	28	-
ER + 50% Def.	26	16	34	-	29	20	27	-
LSD .05	5	5	5		7	7	4	

Table A9. Dry weight of leaves (gm plant^{-1}) at each collection of field-grown single plants of maize genotypes; expressed as the mean of eight replications, 1978 and 1979 seasons

	1978				1979			
	----Days after treatment----				----Days after treatment----			
	10	20	30	40	10	20	30	40
	gm plant^{-1}							
BSSS 56								
Control	38	34	25	-[a]	42	42	34	-
25% Def.	23	25	15	-	26	29	-	-
50% Def.	18	17	15	-	22	22	-	-
75% Def.	5	4	-	-	3	3	-	-
ER	38	36	-	-	44	44	-	-
ER + 50% Def.	20	17	-	-	21	23	-	-
LSD .05	4	4	5		4	4		
BSSS 114								
Control	36	35	28	-	36	36	26	-
25% Def.	24	20	16	-	23	22	-	-
50% Def.	19	16	11	-	19	18	-	-
75% Def.	6	3	-	-	3	3	-	-
ER	37	34	-	-	33	38	24	-
ER + 50% Def.	22	18	-	-	19	20	12	-
LSD .05	4	3	3		3	3	5	

[a]Treatment senesced or not sampled.

Table A9. (Continued)

	1978				1979			
	----Days after treatment----				----Days after treatment-----			
	10	20	30	40	10	20	30	40
	----------gm plant^{-1}----------							
BSSS 133								
Control	43	36	31	-	37	44	-	-
25% Def.	28	26	24	-	20	23	-	-
50% Def.	22	20	21	-	17	20	-	-
75% Def.	8	7	-	-	4	4	-	-
ER	46	36	-	-	33	40	-	-
ER + 50% Def.	21	19	-	-	19	21	-	-
LSD .05	3	3	3		3	3		
B73 X Mo17								
Control	55	52	47	38	57	60	54	-
25% Def.	43	34	31	22	34	35	24	-
50% Def.	35	27	25	23	26	28	-	-
75% Def.	16	8	-	-	4	4	-	-
ER	61	53	43	-	33	63	44	-
ER + 50% Def.	35	31	27	-	19	32	24	-
LSD .05	6	3	7	5	3	4	4	

Table A9. (Continued)

	1978				1979			
	----Days after treatment----				----Days after treatment----			
	10	20	30	40	10	20	30	40
	----------gm plant^{-1}----------							
Q97 X Q98								
Control	59	52	56	47	66	65	59	-
25% Def.	34	39	31	-	39	38	-	-
50% Def.	25	27	21	19	29	31	24	-
75% Def.	5	5	-	-	4	8	-	-
ER	55	56	56	46	64	74	64	-
ER + 50% Def.	29	28	32	26	37	33	30	-
LSD .05	5	5	7	9	5	5	6	

Table A10. Dry weight of the sheaths (gm plant^{-1}) at each collection of field-grown single plants of maize genotypes; expressed as the mean of eight replications, 1978 and 1979 seasons

	1978				1979			
	----Days after treatment----				----Days after treatment----			
	10	20	30	40	10	20	30	40
	gm plant^{-1}							
BSSS 56								
Control	22	21	21	- [a]	22	20	20	-
25% Def.	21	21	18	-	20	18	-	-
50% Def.	20	21	16	-	20	19	-	-
75% Def.	20	21	-	-	18	15	-	-
ER	24	23	-	-	24	22	-	-
ER + 50% Def.	22	21	-	-	19	21	-	-
LSD .05	2	2	5		2	3		
BSSS 114								
Control	22	23	20	-	23	17	14	-
25% Def.	23	21	20	-	20	16	-	-
50% Def.	22	21	20	-	21	16	-	-
75% Def.	23	20	-	-	19	14	-	-
ER	24	26	-	-	23	22	13	-
ER + 50% Def.	25	24	-	-	21	21	14	-
LSD .05	3	2	2		2	2	3	

[a] Treatment senesced or not sampled.

Table A10. (Continued)

	1978				1979			
	----Days after treatment----				----Days after treatment----			
	10	20	30	40	10	20	30	40
	----------gm plant^{-1}----------							
BSSS 133								
Control	31	30	27	-	25	29	-	-
25% Def.	30	29	29	-	24	24	-	-
50% Def.	28	30	29	-	22	24	-	-
75% Def.	30	28	-	-	22	20	-	-
ER	32	30	-	-	27	26	-	-
ER + 50% Def.	29	30	-	-	22	25	-	-
LSD .05	2	3	3		3	3		
B73 X Mo17								
Control	30	35	31	29	35	31	30	-
25% Def.	33	33	28	31	33	28	21	-
50% Def.	31	34	27	29	29	27	-	-
75% Def.	28	30	-	-	28	25	-	-
ER	30	40	34	-	44	34	29	-
ER + 50% Def.	33	38	34	-	35	31	29	-
LSD .05	5	4	6	4	3	4	5	

Table A10. (Continued)

	1978				1979			
	----Days after treatment----				----Days after treatment----			
	10	20	30	40	10	20	30	40
	----------gm plant^{-1}----------							
Q97 X Q98								
Control	34	33	33	29	32	28	27	-
25% Def.	31	33	30	-	28	27	-	-
50% Def.	32	31	27	25	28	26	24	-
75% Def.	35	30	-	-	27	20	-	-
ER	38	39	39	33	39	37	36	-
ER + 50% Def.	37	36	37	31	40	33	29	-
LSD .05	4	5	7	3	3	4	4	

Table A11. Dry weight of the stalk (gm plant^{-1}) at each collection of field-grown single plants of maize genotypes; expressed as the mean of eight replications, 1978 and 1979 seasons

	1978				1979			
	----Days after treatment----				----Days after treatment----			
	10	20	30	40	10	20	30	40
	----------gm plant^{-1}----------							
BSSS 56								
Control	92	77	71	-[a]	97	105	89	-
25% Def.	80	76	62	-	88	93	-	-
50% Def.	80	74	51	-	88	85	-	-
75% Def.	67	66	-	-	65	56	-	-
ER	110	105	-	-	114	136	-	-
ER + 50% Def.	104	91	-	-	88	106	-	-
LSD .05	10	11	18		12	16		
BSSS 114								
Control	85	78	69	-	85	79	80	-
25% Def.	79	64	56	-	76	70	-	-
50% Def.	76	65	55	-	78	66	-	-
75% Def.	76	56	-	-	69	58	-	-
ER	107	122	-	-	100	114	116	-
ER + 50% Def.	96	103	-	-	90	101	99	-
LSD .05	9	8	7		8	8	14	

[a]Treatment senesced or not sampled.

Table A11. (Continued)

	1978				1979			
	----Days after treatment----				----Days after treatment----			
	10	20	30	40	10	20	30	40
	----------gm plant^{-1}----------							
BSSS 133								
Control	77	74	76	-	74	80	-	-
25% Def.	75	75	76	-	78	71	-	-
50% Def.	70	75	76	-	74	75	-	-
75% Def.	74	69	-	-	70	63	-	-
ER	84	81	-	-	79	80	-	-
ER + 50% Def.	71	75	-	-	75	77	-	-
LSD .05	7	9	8		10	7		
B73 X Mo17								
Control	138	139	124	120	141	142	158	-
25% Def.	132	117	99	94	128	122	96	-
50% Def.	126	110	77	98	119	107	-	-
75% Def.	104	88	-	-	109	86	-	-
ER	177	188	177	-	190	214	213	-
ER + 50% Def.	150	161	161	-	163	184	199	-
LSD .05	20	19	18	21	11	15	19	

Table A11. (Continued)

	1978				1979			
	----Days after treatment----				----Days after treatment----			
	10	20	30	40	10	20	30	40
	----------gm plant^{-1}----------							
Q97 X Q98								
Control	101	87	99	98	106	108	119	-
25% Def.	88	83	86	-	94	99	-	-
50% Def.	85	78	80	81	100	93	99	-
75% Def.	94	68	-	-	94	91	-	-
ER	129	122	138	122	164	174	196	-
ER + 50% Def.	124	108	121	117	146	160	194	-
LSD .05	11	13	16	15	10	11	18	

Table A12. Dry weight of the primary ear (gm plant^{-1}) at each collection of field-grown single plants of maize genotypes; expressed as the mean of eight replications, 1978 and 1979 seasons

	1978				1979			
	---Days after treatment---				---Days after treatment---			
	10	20	30	40	10	20	30	40
	gm plant^{-1}							
BSSS 56								
Control	40	69	79	-[a]	37	64	73	-
25% Def.	43	69	81	-	34	53	-	-
50% Def.	47	51	83	-	37	66	-	-
75% Def.	41	44	-	-	34	56	-	-
LSD .05	8	15	19		10	15		
BSSS 114								
Control	48	91	113	-	63	95	134	-
25% Def.	42	77	95	-	55	89	-	-
50% Def.	43	70	86	-	55	81	-	-
75% Def.	38	50	-	-	37	48	-	-
LSD .05	7	14	4		9	14		
BSSS 133								
Control	22	22	33	-	23	40	-	-
25% Def.	21	25	26	-	23	26	-	-
50% Def.	25	26	35	-	18	32	-	-
75% Def.	24	25	-	-	23	28	-	-
LSD .05	4	6	6		5	10		

[a]Treatment senesced or not sampled.

Table A12. (Continued)

	1978				1979			
	---Days after treatment---				---Days after treatment---			
	10	20	30	40	10	20	30	40
	gm plant^{-1}							
B73 X Mo17								
Control	95	173	223	266	130	193	265	-
25% Def.	96	153	214	242	127	181	225	-
50% Def.	89	137	175	215	114	182	-	-
75% Def.	81	105	-	-	110	112	-	-
LSD .05	11	15	15	32	10	12	11	
Q97 X Q98								
Control	88	144	180	202	101	145	184	-
25% Def.	72	142	142	-	84	136	-	-
50% Def.	73	120	135	-	84	128	149	-
75% Def.	63	88	-	-	64	81	-	-
LSD .05	10	18	21		32	10	12	

Table A13. Dry weight of the secondary ear (gm plant^{-1}) at each collection of field-grown single plants for Q97 X Q98; expressed as the mean of eight replications, 1978 and 1979 seasons

	1978				1979			
	----Days after treatment---				----Days after treatment----			
	10	20	30	40	10	20	30	40
	----------gm plant^{-1}----------							
Q97 X Q98								
Control	45	60	73	19	75	102	63	-[a]
25% Def.	20	30	64	-	43	57	-	-
50% Def.	29	22	29	29	50	60	45	-
75% Def.	22	26	-	-	25	22	-	-
LSD .05	14	12	19	5	11	17	15	

[a]Treatment senesced or not sampled.

Table A14. Treatment means (gm four plants^{-1}) for the measured harvest parameters of field-grown single plants of maize genotypes; expressed as the mean of eight replications, 1978 season

	Primary cob weight	Secondary cob weight	Primary grain weight	Secondary grain weight	Primary 100-kernel weight	Secondary 100-kernel weight
	gm four plants^{-1}					
BSSS 56						
Control	85	-[a]	186	-	23	-
25% Def.	79	-	200	-	23	-
50% Def.	75	-	205	-	25	-
75% Def.	60	-	167	-	19	-
LSD .05	12		38		2	
BSSS 114						
Control	67	-	247	-	19	-
25% Def.	58	-	250	-	18	-
50% Def.	52	-	196	-	17	-
75% Def.	43	-	154	-	15	-
LSD .05	29		34		1	

[a]This harvest parameter was not sampled.

Table A14. (Continued)

	Primary cob weight	Secondary cob weight	Primary grain weight	Secondary grain weight	Primary 100-kernel weight	Secondary 100-kernel weight
	gm four plants^{-1}					
BSSS 133						
Control	73	-	24	-	16	-
25% Def.	76	-	29	-	17	-
50% Def.	67	-	19	-	19	-
75% Def.	72	-	30	-	19	-
LSD .05	5		11		2	
B73 X Mo17						
Control	134	-	751	-	33	-
25% Def.	118	-	675	-	30	-
50% Def.	100	-	551	-	27	-
75% Def.	80	-	380	-	19	-
LSD .05	7		57		3	

Table A14. (Continued)

	Primary cob weight	Secondary cob weight	Primary grain weight	Secondary grain weight	Primary 100-kernel weight	Secondary 100-kernel weight
	gm four plants^{-1}					
Q97 X Q98						
Control	135	66	488	275	28	23
25% Def.	103	61	391	224	23	21
50% Def.	90	53	381	192	23	18
75% Def.	70	37	244	44	18	8
LSD .05	10	13	39	69	2	3

Table A15. Treatment means (gm four plants^{-1}) for the measured harvest parameters of field-grown single plants of maize genotypes; expressed as the mean of eight replications, 1979 season

	Primary cob weight	Secondary cob weight	Primary grain weight	Secondary grain weight	Primary 100-kernel weight	Secondary 100-kernel weight
	gm four plants^{-1}					
BSSS 56						
Control	118	-[a]	254	-	25	-
25% Def.	92	-	251	-	27	-
50% Def.	88	-	202	-	26	-
75% Def.	63	-	158	-	23	-
LSD .05	8		45		3	
BSSS 114						
Control	92	-	485	-	20	-
25% Def.	67	-	365	-	18	-
50% Def.	62	-	325	-	17	-
75% Def.	48	-	149	-	12	-
LSD .05	7		24		3	

[a]This harvest parameter was not sampled.

Table A15. (Continued)

	Primary cob weight	Secondary cob weight	Primary grain weight	Secondary grain weight	Primary 100-kernel weight	Secondary 100-kernel weight
	gm four plants^{-1}					
BSSS 133						
Control	81	-	103	-	31	-
25% Def.	77	-	124	-	31	-
50% Def.	74	-	110	-	31	-
75% Def.	74	-	101	-	29	-
LSD .05	13		29		2	
B73 X Mo17						
Control	150	-	1129	-	36	-
25% Def.	112	-	803	-	28	-
50% Def.	100	-	654	-	23	-
75% Def.	95	-	385	-	15	-
LSD .05	6		10		3	

Table A15. (Continued)

	Primary cob weight	Secondary cob weight	Primary grain weight	Secondary grain weight	Primary 100-kernel weight	Secondary 100-kernel weight
	gm four plants^{-1}					
Q97 X Q98						
Control	111	73	703	510	28	25
25% Def.	87	51	553	225	22	16
50% Def.	88	65	502	205	21	16
75% Def.	81	42	264	39	19	4
LSD .05	8	6	30	53	3	2

Table A16. The physiological maturity of the primary ear (days from 50% silking to 75% black layer development) of field-grown single plants of maize genotypes; expressed as the mean of eight replications, 1978 and 1979 seasons

	1978	1979
	Days from 50% silking to 75% black layer development	
BSSS 56		
Control	43	54
25% Def.	43	54
50% Def.	43	54
75% Def.	39	43
LSD .05	1	4
BSSS 114		
Control	38	52
25% Def.	38	45
50% Def.	36	45
75% Def.	29	36
LSD .05	3	5
BSSS 133		
Control	41	63
25% Def.	41	63
50% Def.	40	63
75% Def.	38	58
LSD .05	1	2

Table A16. (Continued)

	1978	1979
	Days from 50% silking to 75% black layer development	
B73 X Mo17		
Control	47	62
25% Def.	42	51
50% Def.	38	44
75% Def.	28	38
LSD .05	6	8
Q97 X Q98		
Control	40	62
25% Def.	38	45
50% Def.	36	48
75% Def.	29	43
LSD .05	4	7

Table A17. Correlation coefficients comparing the CER of the second leaf and the ear leaf with the leaves, sheaths, stalk, primary ear, and secondary ear, 1978 and 1979 seasons

	CER of the second leaf		CER of the ear leaf	
	1978	1979	1978	1979
Leaves				
BSSS 56	-0.14	-0.33**	-0.08	-0.25**
BSSS 114	0.15†	0.06	0.19*	0.15†
BSSS 133	-0.32**	-0.43**	-0.19*	-0.17†
B73 X Mo17	-0.08	-0.06	-0.04	-0.06
Q97 X Q98	-0.16*	-0.10	-0.10	0.20*
Sheaths				
BSSS 56	0.11	0.14	0.08	0.12
BSSS 114	0.20*	0.35**	0.25*	0.38**
BSSS 133	-0.02	-0.23*	0.09	-0.25**
B73 X Mo17	-0.17*	0.19*	-0.17	0.15†
Q97 X Q98	0.11	-0.09	0.11	0.21**
Stalk				
BSSS 56	0.11	-0.20*	0.08	-0.11
BSSS 114	0.09	-0.41**	0.26**	-0.30**
BSSS 133	-0.20*	-0.01	-0.07	-0.18†
B73 X Mo17	-0.36**	-0.37**	-0.36**	-0.42**
Q97 X Q98	-0.25**	-0.37**	-0.06	0.14

†, *, **Significant at the 0.10, 0.05, and 0.01 levels, respectively.

Table A17. (Continued)

	CER of the second leaf		CER of the ear leaf	
	1978	1979	1978	1979
Primary Ear				
BSSS 56	-0.11	0.04	-0.12	-0.03
BSSS 114	-0.12	0.21*	-0.24**	0.21*
BSSS 133	0.01	0.10	-0.003	0.24*
B73 X Mo17	0.26**	0.16†	0.24**	0.19*
Q97 X Q98	0.04	0.15†	-0.11	-0.23**
Secondary Ear				
Q97 X Q98	0.22**	0.25**	0.08	-0.03

Table A18. Correlation coefficents comparing the CER of the second leaf and the ear leaf with the %TNC of the bulk sample of the top three nodes, the singular ear node, and the ear leaf, 1979 season

	CER of the second leaf	CER of the ear leaf
BSSS 114		
Top Three Nodes	-0.14	-0.10
Ear Node	0.02	0.11
Ear Leaf	0.12	0.24**

**Significant at the 0.01 level.

Table A19. Mean squares for the analysis of variance of the CER of the second leaf and the ear leaf, and the TNC of a bulk sample of the top three nodes and the singular ear node for B73 X Mo17, 1978 season , Part I

Source	df	Mean squares			
		CER of the second leaf	CER of the ear leaf	TNC of the top three nodes	TNC of the ear node
Replications	3	65.49	66.21	79.48*	12.19
Collections	9	708.42**	546.28**	317.52**	290.70**
Error (a)	27	39.59	65.71	19.48	17.00
Treatments	2	561.80*	419.32*	23.36	65.23
Treatments X Collections	18	65.15*	49.78	30.15	50.62
Error (b)	60	55.32	48.86	18.54	20.87

*,**Significant at the 0.05 and 0.01 levels, respectively.

Table A20. Mean squares for the analysis of variance of the CER of the second leaf and the ear leaf, and the TNC of a bulk sample of the top three nodes, the singular ear node, and the ear leaf, 1979 season, Part I

		Mean squares				
Source	df	CER of the second leaf	CER of the ear leaf	TNC of the top three nodes	TNC of the ear node	TNC of the leaf
Genotypes (G)	1	1534.7	1969.9	1764.0**	663.1*	592.1*
Replications (R)	3	217.0	285.2	20.1	40.9	57.0
Error (a)	3	214.2	285.9	43.3	55.0	33.3
Collections (C)	5	1775.4**	273.0	370.0**	468.0**	88.3**
G X C	5	130.2	170.9	240.4**	248.3**	47.5*
Error (b)	30	198.1	149.4	24.6	22.3	15.7
Treatments (T)	2	4475.1**	246.8	274.7**	385.8**	232.2**
G X T	2	11.2	179.2	92.7*	49.1	51.2
C X T	10	551.7**	163.4	108.3**	118.3**	24.3
G X C X T	10	221.6*	125.0	44.0	60.6*	27.8
Error (c)	72	103.5	89.5	26.1	27.6	28.9

*,**Significant at the 0.05 and 0.01 levels, respectively.

Table A21. Mean squares for the analysis of variance of the CER of the second leaf and the ear leaf, and the weights of the stalk, leaves, sheaths, primary ear, and secondary ear for the maize genotypes, both seasons, Part II

Source	df	CER of the second leaf	CER of the ear leaf	Mean squares			Primary ear	Secondary ear[a]
				Stalk	Leaves	Sheaths		
Genotypes (G)	4	16,157.8**	23,366.1**	175,450.6**	13,872.5**	8,597.0**	305,783.7**	
Replications (R)	7	388.3**	344.1**	502.1	24.2	22.5	393.7	405.3
Error (a)	28	97.41	82.3	540.7	30.4	20.6	201.0	223.5
Collections (C)	3	19,884.2**	9,603.4**	8,457.9**	376.7	34,791.3**	296,659.0**	3507.1**
G X C	12	2,696.7**	2,374.9**	3,155.7**	243.8**	135.0**	6,115.7**	
Error (b)	84	102.8	77.7	343.4	54.5	24.3	14,618.6	302.7
Treatments (T)	5	4,768.4**	1,617.1**	111,883.0**	45,533.0**	1,215.6**	513,998.3**	33,588.1**
G X T	20	815.3**	848.1**	4,754.0*	322.9**	39.8*	43,955.8**	
C X T	15	51.0	336.2**	6,851.0**	193.3**	41.6*	11,541.3**	1460.8**
G X C X T	60	111.0**	36.2**	2,237.7**	175.4**	31.3*	10,280.0**	
Error (c)	497	47.9	58.5	239.4	27.9	17.1	243.0	

[a]For this parameter, only Q97 X Q98 was analyzed.

*,**Significant at the 0.05 and 0.01 levels, respectively.

Table A22. Mean squares for the analysis of variance of the TNC of the top three nodes and the singular ear node for the maize genotypes, both seasons, Part II

Source	df	Mean squares	
		TNC of the top three nodes	TNC of the ear node
Genotypes (G)	4	1556.1**	1408.7**
Replications (R)	3	53.1	6.6
Error (a)	12	13.9	15.9
Collections (C)	3	1152.2**	1627.3**
C X G	9	539.7**	221.7**
Error (b)	35	14.0	21.5
Treatments (T)	5	2571.0**	1942.4**
T X G	20	141.1**	214.4**
T X G X C	60	62.9**	28.1**
Error (c)	219	14.6	14.0

**Significant at the 0.01 level.

Table A23. Mean squares for the analysis of variance for the measured yield parameters for the maize genotypes, both seasons, Part II

Source	df	Mean Squares					
		Primary cob weight	Secondary cob weight	Primary grain weight	Secondary grain weight	Primary 100-kernel weight	Secondary 100-kernel weight
Genotypes (G)	4	23,922.6**	40,140.8**	1,957,094.6**	587,302.1**	846.9**	3,427.6**
Replications (R)	7	221.5	41.5	583.9	467.7	28.2**	0.8
Error (a)	28	181.3	41.5	3,382.8	467.7	7.4	0.8
Treatments (T)	3	18,243.2**	496.7**	774,722.9**	66,111.5**	690.9**	186.1**
T X G	12	308.8**	496.7**	143,963.5**	66,111.5**	132.8**	1.6
Error (b)	105	96.1	25.4	1,914.6	1,008.9	8.2	

**Significant at the 0.01 level.